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A DEFENCE OF PRAGMATISM[1]

I. Its Mediating Office

By Professor WILLIAM JAMES
Harvard University

IN the preface to that admirable collection of essays of his called *Heretics,* Mr. Chesterton writes these words:

> There are some people—and I am one of them—who think that the most practical and important thing about a man is still his view of the universe. We think that for a landlady considering a lodger, it is important to know his income, but still more important to know his philosophy. We think that for a general about to fight an enemy, it is important to know the enemy's numbers, but still more important to know the enemy's philosophy. We think the question is not whether the theory of the cosmos affects matters, but whether in the long run anything else affects them.[2]

I think with Mr. Chesterton in this matter. I know that you, ladies and gentlemen, have a philosophy, each and all of you, and that the most interesting and important thing about you is the way in which it determines the perspective in your several worlds. You know the same of me. And yet I confess to a certain tremor at the audacity of the enterprise which I am about to begin. For the philosophy which is so important in each of us is not a technical matter, it is our more or less dumb sense of what life honestly and deeply means. It is only partly got from books; it is our individual way of just seeing and feeling the total push and pressure of the cosmos.

[1] The first of a course of eight lectures on 'Pragmatism: A new name for an old way of thinking,' given before the Lowell Institute, Boston, and the Departments of Philosophy and Psychology, Columbia University.

[2] G. K. Chesterton, 'Heretics,' London and New York, 1905, p. 15.

I have no right to assume that many of you are students of the cosmos in the class-room sense, yet here I stand desirous of interesting you in a philosophy which to no small extent has to be technicaly treated. I wish to fill you with sympathy with a contemporaneous tendency in which I profoundly believe, and yet I have to talk like a professor to you who are not students. Whatever universe a professor believes in must at any rate be a universe that lends itself to lengthy discourse. A universe definable in two sentences is something for which the professorial intellect has no use. No faith in anything of that cheap kind! I have heard friends and colleagues try to popularize philosophy in this very hall, but they soon grew technical, and then dry, and the results were only partially encouraging. So my enterprise is a bold one. The founder of pragmatism himself recently gave a course of lectures at the Lowell Institute with that very word in its title—flashes of brilliant light relieved against Cimmerian darkness! None of us, I fancy, understand *all* that he said—yet here I stand, making a very similar venture.

I risk it because the very lectures I speak of *drew*—they brought good audiences. There is, it must be confessed, a curious fascination in hearing deep things talked about, even though neither we nor the disputants understand them. We get the problematic thrill, we feel the presence of the vastness. Let a controversy begin in a smoking-room anywhere, about free-will or God's omniscience, or good and evil, and see how every one in the place pricks up his ears. Philosophy's results concern us all most vitally, and philosophy's queerest arguments tickle agreeably our sense of subtlety and ingenuity.

Believing in philosophy myself devoutly, and believing also that a kind of new dawn is breaking upon us philosophers, I feel impelled, *per fas aut nefas,* to try to impart to you some news of the situation.

Philosophy is at once the most sublime and the most trivial of human pursuits. It both works in the minutest crannies and opens out the widest vistas. It 'bakes no bread,' as has been said, but it can inspire our souls with courage; and repugnant as its manners, its doubting and challenging, its quibbling and dialectics, often are to common people, no one of us can get along without the far-flashing beams of light it sends over the world's perspectives. These illuminations, at least, and the contrast-effects of darkness and mystery that accompany them, give to what it says an interest that is more than professional or technical.

The history of philosophy is to a great extent that of a certain clash of human temperaments. Undignified as such a treatment may seem to some of my colleagues, I shall have to take account of this clash and explain a good many of the divergencies of philosophers by it. Of whatever temperament a professional philosopher is, he tries

when philosophizing to sink the fact of his temperament. Temperament is no conventionally recognized reason, and he urges impersonal reasons only for his conclusions. Yet his temperament really gives him a stronger bias than any of his more strictly objective premises. It loads the evidence for him one way or the other, making for a more sentimental or a more hard-hearted view of the universe, just as this or that fact or principle would. He *trusts* his temperament. Wanting a universe that suits it, he believes in any representation of the universe that does suit it. He feels men of opposite temper to be out of key with the world's character, and in his heart considers them incompetent, and 'not in it,' in the philosophic business, even though they may far excel him in dialectical ability.

Yet in the forum he can make no claim, on the bare ground of his temperament, to superior discernment or authority. There arises thus a certain insincerity in the philosophic discussion. The potentest of all our premises is never mentioned. I am sure it would contribute to clearness if in these lectures we should break this rule and mention it, and I accordingly feel free to do so.

Of course I am talking here of very positively marked men, men of radical idiosyncracy, who have set their stamp and likeness on philosophy and figure in its history. Plato, Locke, Hegel, Spencer, are such temperamental thinkers. Most of us have, of course, no very definite intellectual temperament, we are a mixture of opposite ingredients, each one present very moderately. We hardly know our own preferences, in abstract matters; some are easily talked out of them, and end by following the fashion or taking up with the beliefs of the most impressive philosopher in their neighborhood, whoever he may be. But the one thing that has *counted* so far in philosophy is that a man should *see* things, see them straight in his own peculiar way, and be dissatisfied with any opposite way of seeing them. There is no reason to suppose that this strong temperamental vision is from now onward to count no longer in the history of man's beliefs.

Now the particular difference of temperament that I have in mind in making these remarks is one that has counted in literature, art, government and manners as well as in philosophy. In manners we find formalists and free and easy persons. In government, authoritarians and anarchists. In literature, purists or academicals, and realists. In art, classics and romantics. You recognize these contrasts as familiar; well, in philosophy we have a very similar contrast expressed in the pair of terms 'rationalist' and 'empiricist,' 'empiricist' meaning your lover of facts in all their crude variety, 'rationalist' meaning your devotee to abstract and eternal principles. No one can live an hour without both facts and principles, so it is a difference rather of emphasis, yet it breeds antipathies of the most

pungent character between those who lay the emphasis differently; and we shall find it extraordinarily convenient to express a certain contrast in men's ways of taking their universe, by talking of the 'empiricist' and of the 'rationalist' temper. These terms make the contrast simple and massive.

More simple and massive than are usually the men of whom the terms are predicated. For every sort of permutation and combination is possible in human nature; and if I now proceed to define more fully what I have in mind when I speak of rationalists and empiricists, by adding to each of those titles some secondary qualifying characteristics, I beg you to regard my conduct as to a certain extent arbitrary. I select types of combination that nature offers very frequently, but by no means uniformly, and I select them solely for their convenience in helping me to my ulterior purpose of characterizing pragmatism. Historically we find the terms 'intellectualism' and 'sensationalism' used as synonyms of 'rationalism' and 'empiricism.' Well, nature seems to combine most frequently with intellectualism an idealistic and optimistic tendency. Empiricists on the other hand are not uncommonly materialistic, and their optimism is apt to be decidedly conditional and tremulous. Rationalism is always monistic. It starts from wholes and universals and makes much of the unity of things. Empiricism starts from the parts, and makes of the whole a collection —is not averse therefore to calling itself pluralistic. Rationalism usually considers itself more religious than empiricism, but there is much to say about this claim, so I merely mention it. It is a true claim when the individual rationalist is what is called a man of feeling, and when the individual empiricist prides himself on being hard-headed. In that case the rationalist will usually also be in favor of what is called free-will, and the empiricist will be a fatalist—I use the terms most popularly current. The rationalist finally will be of dogmatic temper in his affirmations, while the empiricist may be more sceptical and open to discussion.

I will write these traits down in two columns. I think you will practically recognize the two types of mental make-up that I mean if I head the columns by the titles 'tender-minded' and 'tough-minded' respectively.

THE TENDER-MINDED	THE TOUGH-MINDED
Rationalistic (going by 'principles'),	Empiricist (going by 'facts'),
Intellectualistic,	Sensationalistic,
Idealistic,	Materialistic,
Optimistic,	Pessimistic,
Religious,	Irreligious,
Freewillist,	Fatalistic,
Monistic,	Pluralistic,
Dogmatical.	Sceptical.

Pray postpone for a moment the question whether the two contrasted mixtures which I have written down are each inwardly coherent and self-consistent or not—I shall very soon have a good deal to say on that point. It suffices for our immediate purpose that tender-minded and tough-minded people, characterized as I have written them down, do both exist. Each of you probably knows some well-marked example of each type, and you know what each example thinks of the example on the other side of the line. They have a low opinion of each other. Their antagonism, whenever as individuals their temperaments have been intense, has formed in all ages a part of the philosophic atmosphere of the time. It forms a part of the philosophic atmosphere to-day. The tough think of the tender as sentimentalists and soft-heads. The tender feel the tough to be unrefined, callous, or brutal. Their mutual reaction is very much like that that takes place when Bostonian tourists mingle with a population like that of Cripple Creek. Each type believes the other to be inferior to itself; but disdain in the one case is mingled with amusement, in the other it has a dash of fear.

Now, as I have already insisted, few of us are tender-foot Bostonians pure and simple, and few are typical Rocky Mountain toughs, in philosophy. Most of us have a hankering for the good things on both sides of the line. Facts are good, of course—give us lots of facts. Principles are good—give us plenty of principles. The world is indubitably one if you look at it in one way, but as indubitably is it many, if you look at it in another. It is both one and many—let us adopt a sort of pluralistic monism. Everything, of course, is necessarily determined, and yet of course our wills are free: a sort of free-will determinism is the true philosophy. The evil of the parts is undeniable; but the whole can't be evil: so practical pessimism may be combined with metaphysical optimism. And so forth—your ordinary philosophic layman never being a radical, never straightening out his system, but living vaguely in one plausible compartment of it or another to suit the temptations of successive hours.

But some of us are more than mere laymen in philosophy. We are worthy of the name of amateurs, and are vexed by too much inconsistency and vacillation in our creed. We cannot preserve a good intellectual conscience so long as we keep mixing incompatibles from opposite sides of the line.

And now I come to the first positively important point which I wish to make. Never were as many men of a decidedly empiricist proclivity in existence as there are at the present day. Our children, one may say, are almost born scientific. But our esteem for facts has not neutralized in us all religiousness. It is itself almost religious. Our scientific temper is devout. Now take a man of this type, and

let him be also a philosophic amateur, unwilling to mix a hodge-podge system after the fashion of a common layman, and what does he find his situation to be in this blessed year 1906? He wants facts; he wants science; but he also wants a religion. And being an amateur and not an independent originator in philosophy he naturally looks for guidance to the experts and professionals whom he finds already in the field. A very large number of you here present, possibly a majority of you, are amateurs of just this kind.

Now what sorts of philosophy do you find actually offered to meet your need? You find an empirical philosophy that is not religious enough, and a religious philosophy that is not empirical enough for your purpose. If you look to the quarter where facts are most considered you find the whole tough-minded program in operation, and the 'conflict between science and religion' in full blast. Either it is that Rocky Mountain tough of a Haeckel with his materialistic monism, his ether-god and his jest at *our* God as a 'gaseous vertebrate,' or it is Spencer treating the world's history as a redistribution of matter and motion solely, and bowing religion politely out at the front door: she may indeed continue to exist, but she must never show her face inside the temple.

For one hundred and fifty years past the progress of science has seemed to mean the enlargement of the material universe and the diminution of man's importance. The result is what one may call the growth of naturalistic or positivistic feeling. Man is no lawgiver to nature, he is an absorber. She it is who stands firm; he it is who must accommodate himself. Let him record truth, cold though it be, and submit to it! The romantic human spontaneity is gone, the vision is materialistic and depressing. Ideals appear as inert by-products of physiology, what is higher is explained by what is lower and treated forever as a case of 'nothing but'—nothing but something else of a quite inferior sort. You get, in short, a materialistic universe, in which only the radically tough-minded can live congenially.

If now, on the other hand, you turn to the religious quarter for consolation, and take counsel of the tender-minded philosophies, what do you find?

Religious philosophy in our day and generation is, among us English-reading people, of two main types. One of these is more radical and aggressive, the other has more the air of fighting a slow retreat. By the more radical wing of religious philosophy I mean the so-called transcendental idealism of the Anglo-Hegelian school, the philosophy of such men as Green, the Cairds, Bosanquet and Royce. This philosophy has greatly influenced the more studious members of our protestant ministry. It is pantheistic, and undoubtedly it has already blunted the edge of the traditional theism in protestantism at large.

That theism remains, however. It is the lineal descendent, through one stage of concession after another, of the dogmatic scholastic theism still taught rigorously in the seminaries of the Catholic Church. For a long time it used to be called among us the philosophy of the Scottish school. It is what I meant by the philosophy that has the air of fighting a slow retreat. Between the encroachments of the Hegelians and other 'philosophers of the absolute,' on the one hand, and those of the scientific evolutionists and agnostics, on the other, the men that give us this kind of a philosophy, James Martineau, Professor Bowne, Professor Ladd and others, must feel themselves rather tightly squeezed. Fair-minded and candid as you like, this philosophy is not radical in temper. It is eclectic, a thing of compromises, that seeks a *modus vivendi* above all things. It accepts the facts of Darwinism, the facts of cerebral physiology, but it does nothing active or enthusiastic with them. It lacks the victorious and agressive note. It lacks *prestige* in consequence, whereas absolutism has a certain *prestige* due to the more radical style of it.

These on the whole are what you have to choose between if you turn to the tender-minded school. And if you are the lovers of facts I have supposed you to be, you find the trail of the serpent of rationalism, of intellectualism, over everything that lies on that side of the line. You escape indeed the materialism that goes with the reigning empiricism; but you pay for your escape by losing contact with the concrete parts of life. The more absolutistic philosophers dwell on so high a level of abstraction that they never even try to come down. The absolute mind which they offer us, the mind that makes our universe by thinking it, might, for all they ever tell us to the contrary, have made any one of a million other universes just as well as this. You can deduce no single actual particular from the notion of it. It is compatible with any state of things whatever being true here below. And the theistic God is almost as sterile a principle. You have to go to the world which he has created to get any inkling of his actual character, he is the kind of God that has once for all made that kind of a world. Yet the theistic writers do not replace the old rationalist definitions of him by any new empirical constructions. Their system still lives on purely abstract heights. Absolutism has a certain sweep and dash about it, while the usual theism is more 'insipid.' But both are equally remote and vacuous. What *you* want is a philosophy that will not only exercise your powers of intellectual abstraction, but that will also make connection with this actual world of our own finite human experiences.

You want a system that will combine both things, the scientific loyalty to facts and willingness to take account of them, the spirit of adaptation and accommodation, in short, but also the old confidence

in human values and the resultant spontaneity—and this is then your dilemma. You find the two parts of your *quæsitum* hopelessly separated, you find empiricism with irreligion; or else a rationalistic philosophy that indeed may call itself religious but that keeps out of all definite touch with concrete facts and joys and sorrows.

I am not sure how many of you live close enough to philosophy to realize fully what I mean by the last reproach, so I will dwell a little longer on that unreality in all rationalistic systems by which your serious believer in facts is so apt to feel repelled.

I wish that I had saved the first couple of pages of a thesis which a student handed me a year or two ago. They illustrated my point so clearly that I am sorry I can not read them to you now. This young man, who was a graduate of some western college, began by saying that he had always taken for granted that when you entered a philosophic class-room you had to open relations with a universe entirely distinct from the one you left behind you in the street. The two were supposed, he said, to have so little to do with each other, that you could not possibly occupy your mind with them at the same time. The world of concrete personal experiences to which the street belongs is multitudinous beyond imagination, tangled, muddy, painful and perplexed. The world to which your philosophy-professor introduces you is simple, clean and noble. The contradictions of real life are absent from it. Its architecture is classic. Principles of reason trace its outlines, logical necessities cement its parts. Purity and dignity are what it most expresses. It is a kind of marble temple shining on a hill.

In point of fact it is far less an account of this actual world than a clear addition built upon it, a classic sanctuary in which the rationalist fancy may take refuge from the intolerably confused and gothic character which mere facts present. It is no *explanation* of our concrete universe, it is another thing altogether, a substitute for it, a remedy, a way of escape.

Its temperament, if I may use the word temperament here, is utterly alien to the temperament of existence in the concrete. *Refinement* is what characterizes our intellectualist philosophies. They exquisitely satisfy that craving for a refined object of contemplation which is so powerful an appetite of the mind. But I ask you in all seriousness to look abroad on this colossal universe of concrete facts, on their awful bewilderments, their surprises and cruelties, on the wildness which they show, and then to tell me whether 'refined' is the one inevitable adjective that springs to your lips, when you endeavor to express the temperament of what you see.

Refinement has its place in things, true enough. But a philosophy that breathes out nothing but refinement will never satisfy the em-

piricist temper of mind. It will seem rather a monument of artificiality. So we find men of science preferring to turn their backs on metaphysics as on something altogether cloistered and spectral, and practical men shaking philosophy's dust off their feet and following the call of the wild.

Truly there is something a little ghastly in the satisfaction with which a pure but unreal system will fill a rationalist mind. Leibnitz was a rationalist mind, with infinitely more interest in facts than most rationalist minds can show. Yet if you wish for superficiality incarnate, you have only to read that charmingly written Theodicée of his, in which he sought to justify the ways of God to man, and to prove that the world we live in is the best of possible worlds. Let me quote a specimen of what I mean.

Among other obstacles to his optimistic philosophy, it falls to Leibnitz to consider the number of the eternally damned. That it is infinitely greater, in our human case, than that of those saved he assumes as a premise from the theologians, and then proceeds to argue in this way. Even then, he says:

> The evil will appear as almost nothing in comparison with the good, if we once consider the real magnitude of the City of God. Coelius Secundus Curio has written a little book, 'De Amplitudine Regni Cœlestis,' which was reprinted not long ago. But he failed to compass the extent of the kingdom of the heavens. The ancients had small ideas of the works of God. . . . It seemed to them that only our Earth had inhabitants, and even the notion of our antipodes gave them pause. The rest of the world for them consisted of some shining globes and a few crystalline spheres. But to-day, whatever be the limits that we may grant or refuse to the Universe we must recognize in it a countless number of globes, as big as ours or bigger, which have just as much right as it has to support rational inhabitants, though it does not follow that they need all be men. Our earth is only one among the six principal satellites of our sun. As all the fixed stars are suns, one sees how small a place among visible things our earth takes up, since it is only a satellite of one among them. Now all these suns *may* be inhabited by none but happy creatures; and nothing obliges us to believe that the number of damned persons is very great; for *a very few instances and samples would suffice for the utility which good draws from evil.* Moreover, since there is no reason to suppose that there are stars everywhere, may there not be a great space beyond the region of the stars? And this immense space, surrounding all this region, . . . may be replete with happiness and glory. . . . What now becomes of the consideration of our Earth and of its denizens? Does it not dwindle to something incomparably less than a physical point, since our earth is but a point compared with the distance of the fixed stars. Thus the part of the universe which we know, being almost lost in nothingness compared with that which is unknown to us, and yet which we are obliged to admit; and all the evils that we know lying in this almost-nothing; it follows that the evils may be almost-nothing in comparison with the goods that the Universe contains.

Leibnitz continues elsewhere:

> There is a kind of justice which aims neither at the amendment of the criminal, nor at furnishing an example to others, nor at the reparation of the

injury. This justice is founded in pure fitness, which finds a certain satisfaction in the expiation of a wicked deed. The Socinians and Hobbes objected to this punitive justice, which is properly vindictive justice and which God has reserved for himself at many junctures. . . . It is always founded in the fitness of things, and satisfies not only the offended party, but all wise lookers-on, even as beautiful music or a fine piece of architecture satisfies a well-constituted mind. It is thus that the torments of the damned continue, even though they serve no longer to turn any one away from sin, and that the rewards of the blest continue, even though they confirm no one in good ways. The damned draw to themselves ever new penalties by their continuing sins, and the blest attract ever fresh joys by their unceasing progress in good. Both facts are founded on the principle of fitness, . . . for God has made all things harmonious in perfection as I have already said.

Leibnitz's feeble grasp of reality is too obvious to need comment from me. It is evident that no realistic image of the experience of a damned soul had ever entered his mind. Nor had it occurred to him that the smaller is the number of 'samples' of the genus lost-soul whom God throws as a sop to the eternal fitness, the more unequitably grounded is the glory of the blest. What he gives us is a cold literary exercise, whose cheerful substance even hell-fire does not warm.

And do not tell me that to show the shallowness of rationalist philosophizing I have had to go back to a shallow wigpated age. The optimism of present-day rationalism sounds just as shallow to the fact-loving mind. The actual universe is a thing wide open, but rationalism makes systems, and systems must be closed. Perfection for men in practical life is something far off and still in process of achievement. This for rationalism is but the illusion of the finite and relative. The absolute ground of things is a perfection eternally complete.

I find a splendid example of revolt against the airy and shallow optimism of current religious philosophy in a publication of that valiant anarchistic writer Morison I. Swift. Mr. Swift's anarchism goes a little farther than mine does, but I confess that I sympathize a good deal, and some of you, I know, will sympathize heartily with his dissatisfaction with the idealistic optimisms now in vogue. He begins his pamphlet on 'Human Submission' with a series of city reporter's items from newspapers (suicides, deaths from starvation and the like) as specimens of our civilized régime. For instance:

After trudging through the snow from one end of the city to the other in the vain hope of securing employment, and with his wife and six children without food and ordered to leave their home in an upper east-side tenement house because of non-payment of rent, John Corcoran, a clerk, to-day ended his life by drinking carbolic acid. Corcoran lost his position three weeks ago through illness and during the period of idleness his scanty savings disappeared. Yesterday he obtained work with a gang of city snowshovelers, but he was too weak

from illness and was forced to quit after an hour's trial with the shovel. Then the weary task of looking for employment was again resumed. Thoroughly discouraged, Corcoran returned to his home last night to find his wife and children without food and the notice of dispossession on the door. On the following morning he drank the poison.

The records of many more such cases lie before me [Mr. Swift goes on]; an encyclopedia might easily be filled with their kind. These few I cite as an interpretation of the Universe. 'We are aware of the presence of God in his world' says a writer in a recent English review. [The very presence of ill in the temporal order is the condition of the perfection of the eternal order, writes Professor Royce ('The World and the Individual,' II., 385).] 'The Absolute is the richer for every discord and for all the diversity which it embraces,' says F. H. Bradley ('Appearance and Reality,' 204). He means that these slain men make the universe richer, and that is philosophy. But while Professors Royce and Bradley and a whole host of guileless thoroughfed thinkers are unveiling Reality and the Absolute and explaining away evil and pain, this is the condition of the only beings known to us anywhere in the universe with a developed consciousness of what the universe is. What these people experience *is* Reality. It gives us an absolute phase of the universe. It is the personal experience of those best qualified in our circle of knowledge to *have* experience, to tell us *what is*. Now what does *thinking about* the experience of these persons come to, compared to directly and personally feeling it as they feel it? The philosophers are dealing in shades, while those who live and feel know truth. And the mind of mankind —not yet the mind of philosophers and of the proprietary class—but of the great mass of the silently thinking men and feeling men, is coming to this view. They are judging the universe as they have hitherto permitted the hierophants of religion and learning to judge *them*. . . .

This Cleveland workingman, killing his children and himself, is one of the elemental stupendous facts of this modern world and of this universe. It can not be glozed over or minimized away by all the treatises on God, and Love, and Being, helplessly existing in their monumental vacuity. This is one of the simple irreducible elements of this world's life, after millions of years of opportunity and twenty centuries of Christ. It is in the mental world what atoms or sub-atoms are in the physical, primary, indestructible. And what it blazons to man is the imposture of all philosophy which does not see in such events the consummate factor of all conscious experience. These facts invincibly prove religion a nullity. Man will not give religion two thousand centuries or twenty centuries more to try itself and waste human time. Its time is up; its probation is ended; its own record ends it. Mankind has not æons and eternities to spare for trying out discredited systems. . . . What is man that thou art mindful of him? Why, the answer is that thou art not mindful of him. Thou permittest him to die like a weed, though with all the fiery sorrow that a sentient being can feel.[3]

Such is the reaction of an empiricist mind upon the rationalist bill of fare. It is an absolute 'No, I thank you.' 'Religion,' says Mr. Swift, 'is like a sleep walker to whom actual things are blank.' And such, though possibly less tensely charged with feeling, is the verdict of every seriously inquiring amateur in philosophy to-day who turns to the philosophy-professors for the wherewithal to satisfy the fullness of his nature's needs. Empiricist writers give him a material-

[3] Morrison I. Swift, 'Human Submission,' Part Second, Philadelphia, Liberty Press, 1905, pp. 4–10.

ism, rationalists give him something religious, but to that religion 'actual things are blank.' He becomes thus the judge of us philosophers. Tender or tough, he finds us wanting. None of us may treat his verdicts disdainfully, for after all, his is the typically perfect mind, the mind the sum of whose demands is greatest, the mind whose criticisms and dissatisfactions are fatal in the long run.

It is at this point that my own solution begins to appear. I offer the oddly-named thing pragmatism as a philosophy that can satisfy both kinds of demand. It can remain religious like the rationalisms, but at the same time, like the empiricisms, it can preserve the richest intimacy with facts. I hope I may be able to leave many of you with as favorable an opinion of it as I preserve myself. Yet, as I am near the end of my hour, I will not introduce pragmatism bodily now. I will begin with it on the stroke of the clock next time. I prefer at the present moment to return a little on what I have said.

If any of you here are professional philosophers, and some of you I know to be such, you will doubtless have felt my discourse so far to have been crude in an unpardonable way, in an almost incredible degree. Tender-minded and tough-minded, what a barbaric disjunction! And, in general, when philosophy is all compacted of delicate intellectualities and subtleties and scrupulosities, and when every possible sort of combination and transition obtains within its bounds, what a brutal caricature and reduction of highest things to the lowest possible expression is it to represent its field of conflict as a sort of rough and tumble fight between two hostile temperaments! What a childishly external view! And again, how stupid it is to treat the abstractness of rationalist systems as a crime, and to damn them because they offer themselves as sanctuaries and places of escape, rather than as prolongations of the world of facts. Are not all our theories just remedies and places of escape? And, if philosophy is to be religious, how can she be anything else than a place of escape from the crassness of reality's surface? What better thing can she do than raise us out of our animal senses and show us another and a nobler home for our minds in that great framework of ideal principles subtending all reality, which the intellect divines? How can principles and general views ever be anything but abstract outlines? Was Cologne cathedral built without an architect's plan on paper? Is refinement in itself an abomination? Is concrete rudeness the only thing that's true?

Believe me, I feel the full force of the indictment. The picture I have given is indeed monstrously over-simplified and rude. But like all abstractions, it will prove to have its use. If philosophers can treat the life of the universe abstractly, they must not complain of an abstract treatment of the life of philosophy itself. In point of fact

the picture I have given is, however coarse and sketchy, literally true. Temperaments with their cravings and refusals do determine men in their philosophies, and always will determine them. The details of systems may be reasoned out piecemeal, and when the student is working at a system, he may often forget the forest for the single tree. But when the labor is accomplished, the mind performs its big summarizing act, and the system stands over against one like a living thing, with that strange simple note of individuality which haunts our memory, like the wrath of the man, when a friend or enemy of ours is dead.

Not only Walt Whitman could write 'who touches this book touches a man.' The books of all the great philosophers are like so many men. Our sense of an essential personal flavor in each one of them, typical but indescribable, is the finest fruit of our own accomplished philosophic education. What the system pretends to be is a picture of the great universe of God. What it is,—and oh so flagrantly!—is the revelation of how intensely odd the personal flavor of some fellow creature is. Once reduced to these terms (and all our philosophies get reduced to them in minds made critical by learning) our commerce with the systems reverts to the informal, to the instinctive human reaction of satisfaction or dissatisfaction. We grow as peremptory in our rejection or admission, as when a person presents himself as a candidate for our favor. Our verdicts are couched in as simple adjectives of praise or dispraise. We measure the total character of the universe as we feel it, against the flavor of the philosophy proffered us, and one word is enough.

'Statt der lebendigen Natur,' we say, 'Da Gott die Menschen schuf hinein,'—that nebulous concoction, that wooden, that straight-laced thing, that crabbed artificiality, that musty school-room product, that sick man's dream! Away with it. Away with all of them! Impossible! Impossible!

Our work over the details of his system is indeed what gives us our resultant impression of the philosopher, but it is on the resultant impression itself that we react. Expertness in philosophy is measured by the definiteness of one's summarizing reactions, by the immediate perceptive epithet with which the expert hits such complex objects off. But great expertness is not necessary, for the epithet to come. Few people have definitely articulated philosophies of their own. But almost everyone has his own peculiar sense of a certain total character in the universe, and of the inadequacy fully to match it of the particular systems that he knows. They don't just cover *his* world. One will be too dapper, another too pedantic, a third too much of a job-lot of opinions, a fourth too morbid, and a fifth too cloistered, or what not. At any rate he, and we, know off-hand that such philosophies are out of plumb and out of key and out of 'whack,' and have

no business to speak up in the universe's name. Plato, Locke, Spinoza, Mill, Caird, Hegel—I prudently avoid names nearer home!—I am sure that to many of you, my hearers, these names are little more than reminders of as many curious personal ways of falling short. It would be an obvious absurdity if such ways of taking the universe were actually true.

We philosophers have to reckon with such feelings on your part. In the last resort, I repeat, it will be by them that all our philosophies shall ultimately be judged. The finally victorious way of looking at things will be the most completely *impressive* way to the normal run of minds.

One word more—namely about philosophies necessarily being abstract outlines. There are outlines and outlines, outlines of buildings that are *fat,* conceived in the cube, by their planner, and outlines of buildings invented flat on paper, with the aid of ruler and compass. These remain skinny and emaciated even when set up in stone and mortar, and the outline already suggests that result. An outline in itself is meagre, truly, but it does not necessarily suggest a meagre thing. It is the essential meagreness of *what is suggested* by the usual rationalistic philosophies that moves empiricists to their gesture of rejection. The case of Herbert Spencer's system is much to the point here. Rationalists feel his fearful array of insufficiencies. His dry schoolmaster temperament, the hurdy-gurdy monotony of him, his preference for cheap makeshifts in argument, his lack of education even in mechanical principles, and in general the vagueness of all his fundamental ideas, his whole system wooden, as if knocked together out of cracked hemlock boards—and yet the half of England wants to bury him in Westminster Abbey.

Why? Why does Spencer call out so much reverence in spite of his weakness in rationalistic eyes? Why should so many educated men who feel that weakness, you and I perhaps, wish to see him in the Abbey notwithstanding?

Simply because we feel his heart to be *in the right place* philosophically. His principles may be all skin and bone, but at any rate his books try to mold themselves upon the particular shape of this particular world's carcase. The noise of facts resounds through all his chapters, the citations of fact never cease, he emphasizes facts, turns his face towards their quarter; and that is enough. It means the right *kind* of thing for the empiricist mind.

The pragmatistic philosophy of which I hope to begin talking in another article preserves as cordial a relation with facts, and, unlike Spencer's philosophy, it neither begins nor ends by turning positive religious constructions out of doors. It treats them cordially as well.

I hope I may lead you to find it just the mediating way of thinking that you require.

THE CENTURY PLANT, AND SOME OTHER PLANTS OF THE DRY COUNTRY[1]

By Professor WILLIAM TRELEASE
MISSOURI BOTANICAL GARDEN

IT would be interesting if we might know whether Columbus and his fellow voyagers noticed what is oddly called 'bamboo' by the present islanders, when they first saw the Bahamas in the autumn of 1492. The plant, a striking one even to us, must have seemed still stranger to Europeans at that time, for although Meyer and others have attempted to show that the century plant was known in the Mediterranean country as early as the eleventh century, and claim has even been made to its recognition among the mural paintings of Pompeii, a thousand years earlier still, *Agave* represents an essentially American and very distinct type of vegetation which must have been novel to those travelers into a new world. At any rate—they had little time for botanizing—there is no evidence that this conspicuous element in the Bahamian landscape was among the strange animals and plants that they paraded on their return home, and, curiously enough, it remains to-day without a published description or tenable scientific name.

The discoverers must have seen at least one other species of the same type when, during this first voyage, they found the Greater Antilles; and the busy quarter of a century which followed, with its additions of the Lesser Antilles, upper South America, and a part of the Gulf coast to the map of the world, undoubtedly revealed others.

The native name 'maguey,' which still persists in Porto Rico for a species of the related genus *Furcræa,* was mentioned in Martyr's book of 1516, and seems to have sufficiently impressed itself on the minds of the adventurers to assume a generic quality, for they later transferred it to the fleshy-leaved agaves of Mexico, which the aborigines knew as 'metl,' from which it is easily inferred that they had repeatedly seen and discussed and inquired about these strange fleshy-leaved plants with tall candelabrum-like inflorescence.

The most familiar of these plants in our gardens has long borne the popular name of century plant. Everybody knows it—or thinks that he knows it—to-day. Its rather narrow, somewhat grayish-green leaves have a peculiar curvature and their ends frequently arch downwards in a characteristic hooked form, while the prickles on their margins stand

[1] A lecture delivered in the Field Museum Course at Chicago, on October 13, 1906.

on marked fleshy hummocks, and the short stout end spine is not continued down the border as it is in some species. Perhaps even commoner than the typical form are one with bright yellow stripes down the sides of the leaves, and another with rather faint yellow lines distributed over the surface; and a still finer but much less common variety has a broad stripe of yellow down the center of the leaf. Among the cultivated variegated century plants one yellow-margined form, with the green parts of a darker shade and the end spine long and slender, has been distinguished for half a century under the name *A. picta;* but, as with the variegated forms of *A. Americana,* nothing is known as to its source or the first date of its appearance. Like the unvariegated form, these yellow-margined plants are now becoming established along the Italian Riviera.

When the American aloe, as it has often been called, was a novelty in Europe, its flowering was one of the wonders of the world. Not only did its size and form and the great age reached by some plants before flowering excite interest, but odd rumors seem to have gone abroad concerning its behavior. One of these gives indirect evidence of the long persistence of a colloquial expression familiar to most of us to-day, for Philip Miller, nearly two hundred years ago, gravely assured the British public that the flowers of this plant do not really open with a report like that of firing a gun, the then prevalent impression that they do so probably coming from a misinterpretation of somebody's statement that the flowering of a century plant 'made a great noise.' The phenomenon has now become so common as to attract no attention about the Mediterranean region, on the Channel Islands, and in the warmer parts of our own country, where the plants grow out of doors and flower when they are ten or fifteen years old; but it is still a matter of much interest in the colder countries where they require the protection of glass houses and develop slowly enough to suggest, if not quite to justify, their popular name.

The century plant shares with or even surpasses the true bamboo in its reputation of offering most of the necessities of human life. Food, drink, clothing, building material, forage, military barricades, razor-strops with soap and brush, medicine, pins, needles, paper, glue and a red coloring matter are said to be afforded by it.

It is true that most of the indicated uses may be made of it, but as a matter of fact the real century plant is very little used except for ornament or as a hedge plant, though its leaf fiber is firm, fine and white and used to a limited extent for the better class of cordage or for a stiff thread peculiarly adapted to some of the ornamental lace-work of the Azores and Mediterranean countries. Nearly all its reputed uses actually refer to different if sometimes superficially similar plants which have been mistaken for it, and the literature of '*Agave Americana*' is chaotic enough to tax the patience of even a botanist.

Perhaps the most curious thing that I can say of the real *Agave Americana* is that nobody knows to-day where to seek it as a spontaneous plant, and, except about the Mediterranean, where it has spread extensively, it seems to be found only as an obvious local escape from cultivation. It looks very much as if the Spanish conquerors took home, as one of their first illustrations of the maguey, a decorative rather than a much-used plant, which even then probably existed only in cultivation.

The traveler through that wonderfully interesting dry region to the southwest of us, the Mexican tableland, has his attention attracted by many of these candelabrum-bearing agaves. Even before reaching Laredo, if he go by that gateway into the neighboring republic,

FIG. 1. ODDLY CALLED BAMBOO.

he may see one large species, *A. asperrima.* If he enter by way of El Paso from the east, another, *A. Parryi,* may draw his notice, or, coming from the west, he may have seen another, *A. Palmeri;* and toward Nogales, the entrance point for Sonora, one of the most striking of them, with almost globose clusters of leaves, *A. Huachucensis,* is visible from the train.

One of the most effective of these landscape-making plants covers certain mountain-sides near Tehuacan, a health resort which every visitor to Oaxaca and the wonderful ruins of Mitla passes through after leaving Puebla. Its stately panicles are of a brilliant yellow, and more beautiful than those of the ordinary century plant; and its great rough leaves are so marbled with alternating greener and grayer cross bands that it has received the distinctive name *A. marmorata.*

Elsewhere about the same city, in company with a full dozen other distinguishable agaves, is an abundance of the beautiful little white-leaved plant, now popular in gardens, which was named *A. Verschaffeltii* after its importer, some forty years ago.

FIG 2. AGAVE PICTA.

Even in Mexico it is the planted rather than the wild agaves that attract attention. Hedgerows or dooryard specimens of them are found everywhere, and in the region to the south of the City of Mexico there are many miles of territory seemingly devoted entirely to their cultivation. Phalanx after phalanx of them stretches away to the horizon as the train speeds through, with hardly a sign of other vegetation except for a cottonwood or pepper tree now and then where water happens to occur, or a cypress marking the resting place of the dead. Through this district, centering about the little town of Apam, it is almost exclusively the dark green giant, *A. atrovirens,* which is grown, though, as with extensively cultivated plants elsewhere, in numerous horticultural varieties which look much alike to the botanist but are distinguished by the planter. Over thirty such forms are said to be planted in the plains of Apam. In the immediate suburbs of the capital city, about Tacubaya, and locally elsewhere in this central district, other forms, differing even to the unspecialized eye, are similarly grown in quantity. As one passes to the colder regions of the north or descends from the table-land into the hot country, still other and different looking species of the same type replace *A. atrovirens,* which, however, far outnumbers and surpasses them all in its aggregate farm importance. These plantations

FIG. 3. DOORYARD SPECIMENS.

are the basis of the pulque industry of Mexico—at once a large item in its agricultural wealth, and one of the greatest curses to its peon population, many of whom are kept in poverty and sottishness through it.

A philosophical historian[2] notes that man has never remained content with water as a beverage, and that agriculture, affording a means of obtaining abundant intoxicants as one possible and alluring substitute, has borne the curse of drunkenness in all ages. The discoverers of the new world found the cultivation of the maguey or metl, and the production of a fermented drink, 'octli' or 'pulque,' from its sap,

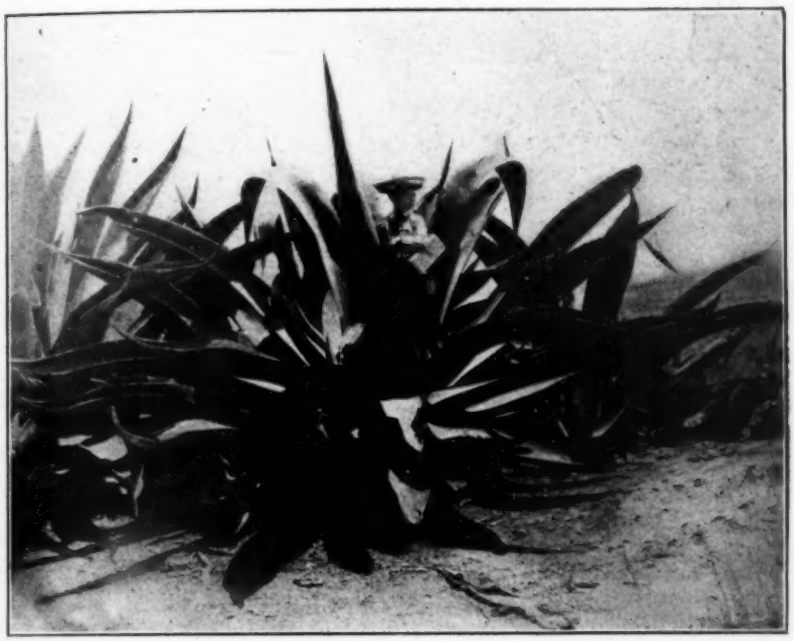

FIG. 4. THE DARK GREEN GIANT.

an established industry, which even then had worked its fatal course with the Toltec race.

The present traffic in pulque is large. Something over five million barrels of it are used in the Mexican republic every year, of which quantity about half is consumed in the capital city and much of the remainder in Puebla and the other large cities of the central plateau. Cheap as it is, for it sells for from one to three cents of Mexican money for a large glass, its aggregate value amounts to several million dollars gold, a year. Special trains are run into the City of Mexico every morning for its delivery, as is done with the milk supply of our own cities.

[2] Payne, 'History of the New World,' 1: 401, 404.

In the Apam district, the plantations are chiefly found on the large haciendas or estates. The first impression of a traveler who passes from Vera Cruz to the capital is likely to be wrong if, as is usually the case, he regard the table-land—so barren after the tropical vegetation in and below the coffee country—as a desert with this strange industry as its one resource. The observant person, however, sees, usually with surprise, enormous stacks of straw here and there in the maguey fields, each commonly marked with a great carved cross or other symbol, and all carefully trimmed into house form; and a shrewd infer-

FIG. 5. IN GARDENS IN SICILY.

ence that where there is a good deal of straw there must be some grain is justified on a closer acquaintance with the country.

A first visit to a Mexican hacienda is an interesting episode in one's traveling experiences. Comfort, as we understand it, is scarcely to be had in the dustier regions during the dry season; and as one looks over the barren country it is hard to see where food is obtained for the swarm of peon retainers for whom even a church is not lacking in the walled village which their dwellings constitute. The wealth of such an estate is found in its extent. I recall the surprise with which,

after a day of blinding dust on a hacienda within sight of the great snow peak of Orizaba, as I asked myself how people could find a living in such a place, I noticed the arrival of a wagon-load of dry fodder in the enclosure, quickly followed by another and another and still others, until some twenty had come in—each drawn by five mules. Then I began to realize the number of draft animals alone that were engaged in bringing in the night's food for the others, and was less surprised when, in droves of twenty or fifty, sheep and cattle began to appear from remote points—until I ceased counting and returned to my original question with even greater wonder. It is on these large estates that the maguey—almost the only green thing to be seen in the long dry season—finds its place as one of the many forms of agricultural resource; the ground between them being frequently made to yield an annual grain or other crop which the agaves supplement as, here and there, they mature one at a time.

The pulque maguey is a large plant, and its rosette of thick leaves, though appearing to lie next the ground, is really spaced along a stout trunk as large as a small barrel. The whole, charged with sap, weighs several tons. If left to itself, as it is in gardens on the Riviera, where it is called *A. Salmiana,* like the century plant it produces a gigantic scape, topped with a candelabrum of flowers, when somewhere in the neighborhood of fifteen years old. This is never permitted on the large plantations, for the plant possesses its maximum value when it has reached vegetative maturity and the scape is about to develop. At the critical moment, known from the appearance of the central bud, this is cut out and a shallow cavity is made in the crown of the trunk, which is covered by a stone, pieces of maguey leaves, or other protection. Into the cavity so formed the sap exudes. It is removed two or three times a day, the surface being scraped and the cavity slightly enlarged each time, until at last nothing but a thin shell of the trunk remains, the leaves meantime having given up their content of fluid and dried to their hard framework—as happens naturally during the flowering period of all the larger agaves, when the reserve of sap is drawn into the rapidly growing scape and flowers.

For a period of three months or more a good plant yields a gallon or two of sap daily, and its value may be not far from ten dollars on an average; from which it will be seen that a large maguey plantation represents a considerable item in the assets of a landed proprietor of the plains of Apam.

Often the peons who cut the matured plants fasten part of the bud leaves on to the spines of the outer ones, so that those in bearing may not be overlooked as the tour of the plantation is made by the laborers who gather the sap. One of these men, making his rounds, is an odd sight. Over his back, usually separated from it by a zarape or blanket if he is fortunate enough to have one, or by a piece of

FIG. 6. A SHELL OF THE TRUNK.

sacking if he is so poor as to feel compelled to reserve his zarape for dress occasions, is swung from his forehead by a head-yoke a pig-skin, supported by a sac, or more usually by a coarse net of cordage, and sticking out from its open top is to be seen a long gourd of the type that we call the Hercules club. In his hand he carries a short curved knife. Plodding from one bearing plant to another, the Indian stops at each long enough to uncover the cavity in its crown, press the smaller end of the gourd to its bottom and, by sucking at the upper end, draw into the lower part of the gourd the exuded sap, and thrust the gourd over his shoulder into the pig-skin bag on his back—his finger meantime stopping the upper hole so that the fluid may not run out until he wishes it to. A quick scraping of the cavity follows, the stone or

other cover is replaced, and he passes on. Sometimes he trudges home with his burden as often as the pig-skin is filled; but on the larger haciendas a burro, saddled with large bags of the same kind, awaits him at one side of the field, and the work continues until at length man and donkey go in with a full load.

The fluid which collects in the hollowed trunk of a cut maguey plant and is gathered in the manner described, is called 'agua miel,' or honey-water, because of its sweetness: nine or ten per cent. of its weight is sugar, and this furnishes the basis for the alcoholic fermentation which is the chief factor in its conversion into pulque. The agua miel of the Apam district is thin, clear and colorless. It is of a rather pleasant taste if dipped from the plant in a gourd and free from drowned insects, but fact or fancy gives it various reminiscent flavors under other circumstances.

The fermentation practises in pulque making are still mostly primitive. I have had a Mexican gentleman tell me that although when the agua miel was gathered and fermented in a way to please him he considered it a delicious drink, he would not think of touching pulque as offered, for instance, at the railway station in Apam—where the conversation occurred. The vats used are of ox-hide stretched on frames, and they are usually three or four feet wide and nearly as deep. Fermentation is begun by the introduction of a starter or 'mother of pulque' obtained by preliminary fermentation, and is carried on without, or at most with little, artificial control of temperature, and under conditions of positive or negative cleanliness which differ with the various haciendas.

When marketed, the pulque is a white, decidedly viscous fluid containing about eight per cent. of alcohol; fermentation has not been solely alcoholic, however, and its flavor is in part due to changes wrought by bacteria of several kinds which are introduced with the starter in company with the yeast. Continuation of the action of these collateral ferments causes the beverage to spoil in a day or two under ordinary conditions.

Familiar sights about Apam and in the capital are wagons loaded with the large casks in which pulque is transported from the haciendas to the railroad and again to the gaudily colored but often disreputable and usually filthy shops where it is dispensed—from open barrels into which glasses are plunged by hand with no greater care to prevent contact with the human person than marks some of the earlier stages in the conversion of grape juice into wine—and the patrons of which are not prepossessing.

Where the maguey, though capable of cultivation, yields a lesser or inferior product, agua miel is often more appreciated in its unfermented state. As hawked around the streets of Monterey, for instance, in porous earthenware receptacles, it is a cool yellowish fluid, that I

must confess I find refreshing on a hot day—especially after I have seen it gathered by means of a long-spouted tin pump and transported in tin cans; and the limpid, yellowish, cidery, foamy product of its fermentation in the north is more to my taste than the white, viscous, odoriferous pulque of the Apam district—which alone pleases the adept.

With smaller production of pulque away from this center, more primitive methods of transportation persist; the shipping cask of the large producer, carried by a special train, may be replaced by the burro-borne pig-skin; and, as I have observed in Tuxpan, the pulque shop may give way to the street hawker, with an earthenware olla, the contents of which from time to time are freshened up by being sucked into and allowed to gush back, frothing, from a gourd of the sort used

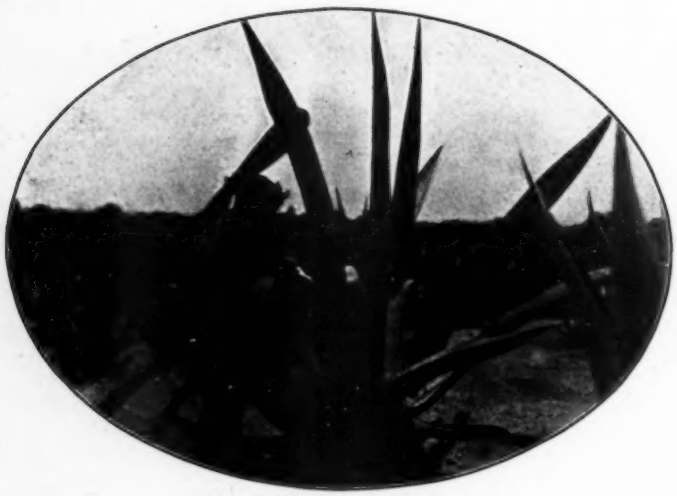

FIG. 7. MAKING HIS ROUNDS.

in gathering the agua miel—the bowls of customers being filled by aid of the same convenient implement.

Considerable medicinal virtue has been claimed for pulque, and some efforts have been made to specially prepare, bottle and Pasteurize it for medicinal or even table use, but, except in the region of its production, where it is the common beverage, the bulk of it is used as an intoxicant, pure and simple. From it is also produced a rather small quantity of distilled liquor, 'mezcal de pulque.'

Away from the central district, where the product of a single plantation is not sufficient to keep a fermentation establishment in profitable operation, it is sometimes the practise of the growers to sell their plants, as they mature, one by one, to a maker of pulque, whose employees, trudging from one to another, attend to cutting them and gathering their sap. Under these conditions, or where the market is still less certain, the plants frequently succeed in sending up their scapes.

FIG. 8. MAN AND DONKEY.

Sometimes flowering is permitted, and the plant yields nothing more than a light rafter-pole, capable of being sliced into good razor-strops, a little green fodder for the cattle, and a few dried leaves that may be used for thatching a hut. At other times the stalk, or 'quiote,' is cut down before the flowers have too far sapped it, stripped of its woody exterior, and cut into disks a few inches long which may be seen peddled around the streets in Durango, for instance—to be split into strips and chewed like sugar-cane. If a distillery is at hand, the leaves are often cut away from a plant of this sort, or one that has not been allowed to form its quiote, above their very thick 'pencas' or bases, and the trunk, so prepared, is marketable for the manufacture of mezcal. From data obtained of a peon, I once figured out that away from the principal pulque region the value of a plant is practically the same whether cut for agua miel or, after harvesting its quiote, sold to the mezcal distillery.

FIG. 10. FROTHING FROM A GOURD.

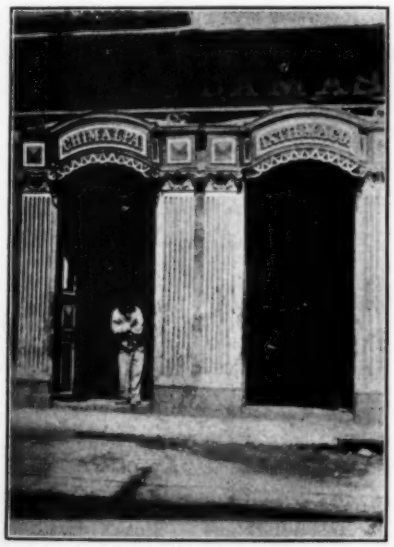

FIG. 9. WHERE PULQUE IS SOLD.

Mezcal is a term applied comprehensively to the liquor obtained by distillation from the fermented juices of agaves. Four or five million gallons of it a year are produced, and its value may amount to some $2,000,000 gold. The center for the manufacture of this beverage is to the west of Guadalajara, and the town of Tequila, situated there, has imposed its name on the higher grade of liquor, which is clear, smoky, rather smooth, and with a characteristic essential flavor; it usually contains forty or fifty per cent. of

alcohol, and, like pulque, possesses certain medicinal properties.

Like pulque, mezcal is sold cheaply. It is to be found everywhere and contributes largely to the demoralization of the native peon, who often drinks it to excess and, like many another human type, commits most of his crimes when influenced by alcohol. Those who watched for the threatened revolution of the sixteenth of September last, probably noticed that the very wise head of the republic forestalled any large demonstration by seeing that drinking places were closed throughout the country.

To supply the distilleries at Tequila, a considerable acreage is planted to mezcal agaves. Those most used there belong to a well-marked, narrow-leaved species which a few years ago received the appropriate and distinctive name *A. Tequilana*. As with the pulque spe-

FIG. 11. QUIOTE. IN DURANGO.

cies, a number of horticultural forms of this are recognized. The leaves are generally glaucous, and a field of these white plants produces a striking effect. If allowed to bloom, this, too, develops a striking and large candelabrum of flowers; but, like the pulque maguey, it is harvested when mature but before its saccharine food reserve has been exhausted in the production of flowers and fruit. The leaves are cut back to their thick bases and the trunks, so trimmed, are packed—usually on mules—to the distillery, where, after a preliminary roasting, still in rather primitive smoky pits, they are converted into a mash which is fermented in large wooden tanks and then distilled in modern apparatus, much as is done in the production of liquors elsewhere. At these modern stills, the bagasse from which the mash has been squeezed by rollers is even packed away by half-naked laborers to be used to feed the furnaces.

In addition to this mezcal de Tequila—or plain 'tequila,' that made direct from the maguey trunks, and the mezcal de pulque already referred to, a great deal of this sort of liquor is made from wild agaves of many kinds, throughout the length and breadth of Mexico; indeed a common if not universal distinction is made between the large 'maguey' species and the smaller ones, which are called 'mezcal' like the beverage obtained from them. The process is everywhere essentially the same in so far as the preliminary roasting and fermenting processes are concerned; but the stills vary from the ordinary retort type in its simplest form, with a 'worm' cooled by flowing water, to the most primitive apparatus by which a paying part of the alcohol may be condensed into fluid form while making its escape from the kettle.

While at Mitla, a few years ago, I was directed to a distillery of this latter kind, not far from the prehistoric ruins for which the place is famed, and my companion and I were permitted to make photographs showing trimmed agave trunks newly brought in from the surrounding mountains and sheltered from the sun while kept in storage, fuel for the roasting pit, the wooden mash barrels and the maul used in crushing the roasted material, the ox-hide fermentation vats supported on rude frames of crooked wood, and the very primitive still of glazed earthenware kettles, set over a crude oven, each capped with a saucer-like metallic cover which was cooled as far as this could be done by a stream of mountain water, while below it a funnel caught the condensed liquor and passed it through a reed spout into a waiting small receptacle.

In northwestern Mexico, 'mezcal' is largely replaced by 'sotol' as the distilled drink of the peon. This liquor, which has the general character of the former, is said to be made in a similar manner from the trunks of several species of the saw-leaved lilies (*Dasylirion*) which are commonly known as sotol and in the stock country are frequently split open to enable animals to get at the pulpy nutritious contents of their stems.

Among the early stories of the new world was an account of the roasting of maguey trunks, and their use as food. They do not appear to be largely used in this manner now, except by the nomadic Indians. In the days of the Apaches, the roasting and eating of mezcal was frequently noted, and the botanist or geologist who gets back into the mountains still occasionally sees it. On our side of the boundary, however, I understand that spectators are not welcomed at a mezcal roast; and the impression has been left on the mind of one of my friends that what was not eaten of the product was likely to undergo fermentation and be saved from becoming a total loss by the aid of the still—a practise on which our government does not smile so complacently as does that of the adjoining republic. Old mezcal pits are

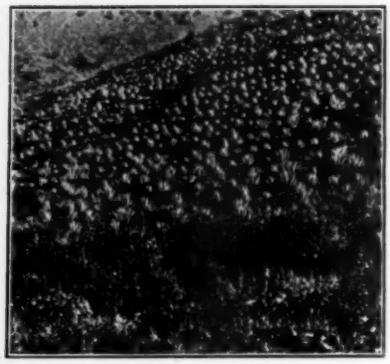

FIG. 12. WHITE PLANTS.

not uncommon in southern Arizona, where *Agave Palmeri* was much eaten; and they are to be seen in the Grand Canyon, in northern Arizona, where *A. Utahensis* is abundant.

The most important economic agaves are not the source of alcohol, but those which yield 'henequen,'—a native name introduced by Oviedo only a few years after Yucatan was discovered. This, so far as Mexico is concerned, is practically a product of Yucatan, though some of the other tropical states yield a small quota, and it has a yearly value of some $30,000,000 gold. A large part of it comes to the United States for use in cordage, etc., under the name 'sisal hemp' or 'sisal grass,' which is derived from a port of shipment. Our imports for the past three years average about $15,000,000 annually.

FIG. 14. SOTOL.

Most of the agaves have a strong fiber in their leaves, the use of which is prehistoric. That of the century plant is particularly white and fine, and, as I have said, is considerably used. The fiber of the pulque species, from the manner in which the sap is gathered, is little used; the very fleshy-leaved species are also hard to clean. The Tequila mezcal is said to produce a good quality of fiber, which —its harvesting not interfering with the main use of the plants— is coming to be regarded as a valuable by-product of this species; and several other agaves are either cultivated on a smaller scale for their fiber or exploited as they occur spontaneously.

FIG. 13. HALF-NAKED LABORERS.

Henequen, however, is *par-excellence the* fiber agave. An interesting minor chapter in our national evolution is contained in the numerous appeals made to Congress about seventy years ago by our former consul at Campeche, Henry Perrine, who desired a land grant in subtropical Florida for the cultivation of this and other tropical plants. The grant cost him his life, for he was killed by the Indians, and the zone of henequen in this country scarcely goes beyond the radius of his own tentative introduction of plants; but the Yucatan industry, which in Dr. Perrine's day was small, though he saw a great future for it if only the fiber could be less laboriously cleaned than it then was by hand, has grown greatly, and the Bahamas, India, Hawaii and tropical Africa are entering the field with more or less realization of their expectations of gain from this crop.

Like the pulque maguey and the Tequila mezcal, henequen is represented in the larger plantations by several horticultural forms if not by more than one distinct species. The one most grown in Yucatan appears to be the taller form with long, narrow, prickly leaves, generally known to foreigners as white or gray henequen—and usually, but wrongly, designated by botanists as *Agave rigida elongata.* A better fiber plant is the entire-leaved green henequen, called *Agave Sisalana* by Perrine, also, but to a smaller extent, grown in Yucatan, and now spontaneous in tropical Florida from Perrine's importation. It is this which has been introduced into the Bahamas and Hawaii, though both the gray and green forms are being experimented with elsewhere.

The utilization of a henequen plant is not effected abruptly at the end of its life, as with the pulque and mezcal species, but, after a wait of five or six years, it extends over a period of from seven to fourteen years, during which the annual yield is said to be from 20 to 40 leaves per plant in several gatherings—the number of mature leaves removed each year determining the longer or shorter period during which cropping may continue. One of the difficulties experienced in trying to cultivate henequen away from the limestone terraces of Yucatan has been that it goes to seed at too early an age, for this ends its usefulness instead of at the same time bringing it to fruition as is the case with the plants grown for pulque or mezcal, though its expiring energy is said to be then thrown into leaf production by cutting out the scape at its inception.

The cultivation of henequen in Yucatan is comparable with that of the maguey on the plains of Apam, in that it is now chiefly in the hands of large proprietors. Plantations are extensive, and the mills for cleaning the fiber are proportionately large. The older leaves are cut, at such intervals and in such numbers as the condition of the plants is thought to warrant, and, after the prickles have been sliced from their edges, trucked or carried on tram roads to the mill, where, while they are still fresh, by means of some form of rotary scraper

(an idea tersely suggested by Perrine, and for the successful application of which, as I read, a large sum was later paid to another) the pulp is removed. The fiber, suitably washed and dried, is then baled for export. In the state of Vera Cruz a plant of the same group has recently come into local prominence, and is said to be considerably planted under the name 'zapupe,' and to yield an excellent fiber.

One of the agaves longest known in gardens is that for which botanists are now restoring the name *A. Vera Cruz* which Miller applied to it, following its earlier polynomial designation of 'Aloe America ex Vera Cruce foliis latioribus et glaucis.' Like the henequen, it yields a fiber for which it is somewhat cultivated in the state of Vera Cruz; and I understand that it is this species to which the *'Agave Americana'* of Indian fiber-culture reports refers.

In India, for a century and a half or more, has been known another agave which is properly called *A. Cantula,* though it is frequently

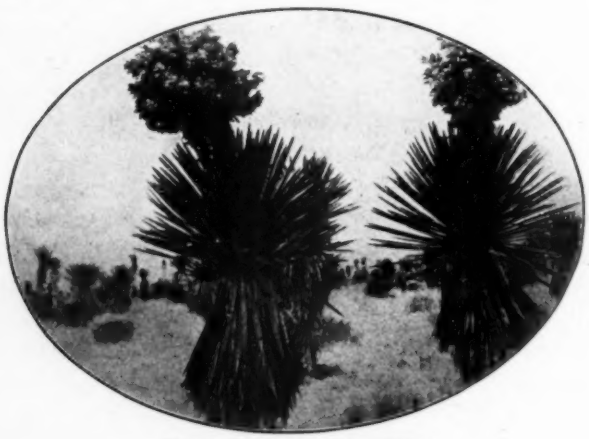

FIG. 15. PALMA ZAMANDOQUE.

spoken of under the name *A. Roxburghii,* which was given to it later. Erroneously, it is even more often designated by the name *A. vivipara,* which, as used by Linnæus, belongs to a very different plant common in the Greater Antilles. This species, the source of a considerable quantity of Indian fiber which is known in the market as Bombay aloe, and of a small but increasing amount of Philippine fiber under the name 'Manila aloe,' is a close relative of the Tequila mezcal. Adequate study will probably result in its final positive identification with some American species; but at present it shares with another Indian species of the same group the distinction of representing in Asia a genus otherwise exclusively American—if the generally discredited hypothesis that the century plant is indigenous to the Mediterranean region be not true.

In comparison with the great cultures of henequen, all of the other

utilization of agaves for fiber is of rather small importance. Nevertheless, considerably more than a million dollars' worth of so-called 'ixtle' fiber is marketed in Mexico each year, in addition to a very large quantity used locally for lassoes and other cordage and the like. From the port of shipment, ixtle is commonly known as Tampico fiber. Our imports for the last three years average about one and a quarter million dollars in value. Unlike henequen, this is the product of several distinct plants, of which a number belong to the very different genera *Yucca, Samuela* and *Hesperaloe,* and in the tropics the name is also applied to *Bromelia* fiber; but the larger part of the Tampico fiber is obtained from two dwarf species of *Agave.* Comparatively little of it comes from large plantations, except in the warm region above Tampico, where extensive planting is now being undertaken—and a large part of the exported ixtle is obtained from this district. Aside from its *Hesperaloe* ('Zamandoque') and *Samuela* ('Palma Zamandoque') constituents, the longer grade of Tampico fiber—which even then is shorter than henequen—seems to be produced chiefly by an agave spontaneous as well as cultivated in the state of Tamaulipas, and known botanically as *A. Funkiana.* In the cooler country, especially in the states of Coahuila and Nuevo Leon, a shorter fiber is obtained from the closely related wild 'lecheguilla,' the native name of which has been adapted by botanists into *Agave Lecheguilla.*

On the plantations, and possibly to a very slight extent elsewhere, the fiber is cleaned by machinery, much as henequen is; but a great deal of it is still prepared laboriously by hand. It is here the central bud or 'cogollo' of young leaves, which is used, and not the harder old ones, and the pulp is removed from the fiber by means of a hand scraper of metal used against a supporting block of wood.

In the northern part of the republic, where, as in western Texas, lecheguilla is extremely abundant over a large area, the extracted fiber, sometimes used for brushes, bath pledgets, etc., is usually spun by hand into cords or these into ropes on a primitive rope-walk, a child twirling the strands as they grow from the apron-like bag of fiber carried by the spinner. This is the common cordage of the country, and is used for tying purposes, lariats and the like, as well as to make sacking, saddle-bags, and the head-yokes with which the human beast of burden always goes provided in that land. Visitors to Monterey are often interested in the rope-walks, which may be seen anywhere in the outskirts of the city, as well as in the manufacture of the lecheguilla cord into coarse bagging which is effected in an equally laborious and simple manner—the cord being woven into oblong mats which are then folded across the middle and stitched down the sides, everything being done by hand. The charm of these simple sights to the tourist is largely enhanced by the general friendliness of the workers, who are usually willing to chat or be photographed and whose

FIG 16. SECHNGUILLA.

affection for their children is an unfailing and very pleasing sight, but the poverty of their homes, only too evident to even the less prying sight-seer, is scarcely compensated for even in this affection —which appears to me the best quality of the Mexican peon.

The lecheguilla agave well pictures a division of the genus in which the flowers are clustered along the upper part of the scape instead of being disposed on the branches of a candelabrum-like top. Of this type is further the 'guapilla'—*A. falcata*—a very narrow-leaved small species of the region about Saltillo, which also yields good ixtle.

The minor uses of agaves are hardly worthy of detailed mention in comparison with their commercially important use as a source of fiber and alcohol. These uses, however, are many, as I have already said. Under the name 'amole' one may buy in most Mexican market places either leaf bases of agaves like *A. filifera* or,

FIG. 17. SPINNING AND WEAVING.

more commonly, rootstocks of the so-called herbaceous species, for use as vegetable soap; the claim has recently been made that the sap from henequen leaves in process of cleaning can be converted into a valuable glue; and from the time of the Aztecs innumerable domestic uses have been found for one part or another of these interesting plants.

So far as inference may go, it was none of the agaves of the earlier discovered West Indies or Yucatan which was first taken across the water, in small specimens for gardeners to care for and grow into some semblance to their native form and size, but one or more species from Mexico proper, to illustrate the wonderful 'metl' of that land. The importation may have been made very soon after the conquest of Mexico by Cortez, but I find no record concerning it. It is even questionable what species was actually first taken over. The first tangible record of an *Agave* in Europe is given by Clusius, a Belgian botanist who, traveling through Spain somewhat more than a generation after the conquest of Mexico, found an aloe of this kind sparingly cultivated at Valencia, where he obtained offsets which he took home, and one of which he figured in 1576. While this first picture probably represents *A. Americana*, as it is usually supposed to do, it must be admitted that it resembles also the common pulque maguey of the table-land, even then an important plant, but which is not known to have been in European gardens before the middle of the century just closed. In 1586 an American aloe flowered at Florence, and was figured by Camerarius two years later. This picture is less questionable than that of Clusius, as representing what we now call the century plant, but it might possibly stand for what, a century later, was grown in Dutch gardens as the broader-leaved aloe from Vera Cruz—now known as *Agave Vera Cruz* or the synonym *A. lurida*. The reported escape of the latter species in central Italy lends some support to this surmise; but the picture can not be said not to represent *A. Americana*, the wide-spread naturalization of which through the Mediterranean countries seems to indicate conclusively that, whichever may have been introduced first, it was really the century plant that was first extensively propagated in Europe.

FIG. 18. WILLING TO BE PHOTOGRAPHED.

The agaves have been esteemed as garden curiosities ever since their

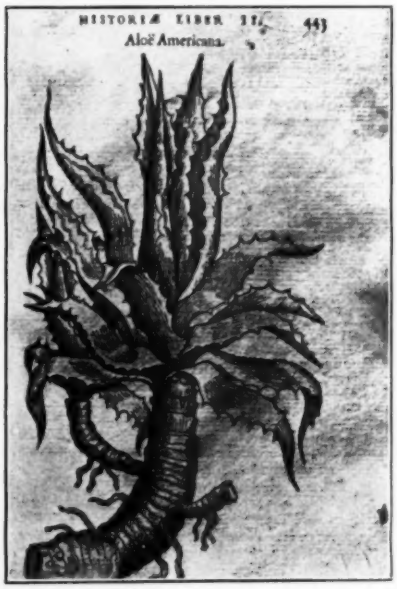

FIG. 19. THE FIRST PICTURE.

first introduction into the civilized world, and many of them are really beautiful plants; but while one of them has leaves only an inch long, the size of others is so great as to render them unsuitable for ordinary cultivation under glass, and really representative collections have been made by only a few amateurs and botanical gardens. About forty years ago a taste for growing some of the smaller species was fostered by Belgian dealers who successfully exhibited and advertised select specimens of new importation, some of which sold for very profitable sums; but I do not recall a single one of the private collections of a generation ago which is still kept up, though fortunately some of the better plants have found their way finally to Kew or some other botanical establishment.

Botanists have generally agreed to date their scientific naming of plants from 1753, when Linnæus substituted the convenient binomial for the awkward if usually terse description that had been used up to that time when reference was made to a plant. This date, consequently, begins the modern history of *Agave*, which, some years earlier, had been segregated from the African genus *Aloe*.

Aloe Americana. Pag. 12.
Huius alterius ex appēdi flore quem ipse non me-
minerit conijci potest. Accurata descriptio extat apud
Cæsalpinum. Nos iconem dedimus, cum hactenus
nemine
hactenus depicta fuerit.
Althæa

FIG. 20. FIGURED BY CAMERARIAS.

In his 'Species Plantarum,' published in that year, Linnæus describes only four species—one of which, the 'cabuja' of the tropical mainland, belongs to a sufficiently distinct genus, *Furcræa*, which was separated from *Agave* half a century later. One of the remaining three is the century plant, *A. Americana;* another is a characteristic large species of the Greater Antilles, *A. vivipara;* the other is an interesting little plant of our own flora, with thin leaves which die down every

winter, and a slender raceme of flowers, *A. Virginica,* which is now made the type of a distinct genus, *Manfreda.* From the two Linnæan species left after the segregation of *Furcræa* and *Manfreda,* the genus *Agave* grew step by step, through later discoveries, to 127 species distinguished by its latest monographer. Of these, 35 belong to the candelabrum group designated as *Euagave* and represented by the two Linnæan species, and 46 have the flower-cluster contracted as in *A. Lecheguilla,* constituting the group *Littæa.* The inflorescence of the remaining 46 was not known when this monograph was written—nearly twenty years ago, and a very large part of the species have been known only through cultivated plants, most of which were described when immature, and of which no inconsiderable number died or were lost sight of before reaching a flowering age.

The describer of a garden species of *Agave* usually finds himself impelled to set down its probable habitat as Mexico. In this guess he is

FIG. 21. HOTEL AT MALTRATA.

favored by the law of chance, for only a few agaves occur to the north or south of Mexico or in the West Indies; but a considerable number of intentional or chance hybrids have originated in gardens in addition to some apparently purely cultural forms, the numerous descriptions of the last two decades are widely scattered and little comparable, and the genus stands to-day as one of the worst confused of its size—the actual number of its species apparently being not far from 200.

There appears little hope of removing this confusion except by protracted field study under unusually difficult conditions, supplemented by garden cultivation of plants from definitely ascertained spontaneous sources. Serviceable herbarium specimens are rarely seen. Their preparation is unusually difficult because of the large size and succulent nature of the plants, but they can be made. The camera is

as indispensable to the field student of these plants as the trowel or drying press, and the data used by whoever may succeed in adequately monographing the agaves will necessarily include habit pictures and full-size details, photographed on the spot.

Anything which takes one into the pure air and bright sunshine of the mountains brings in the enjoyment of these a full compensation for the inseparable hardships of travel in a sparsely settled country where the comforts of life are not to be looked for outside of the larger cities, and where one frequently goes to bed literally with the chickens or is stabled in the barnyard.

The agaves are preeminently plants of rocky places. Some of them delight in hanging from the sides of cliffs which are all but inaccessible. Others grow in the middle of the great fields of broken ragged lava to which the Mexicans have applied the expressive name 'malpays' or bad lands. Collecting under such conditions is scarcely capable of description without the unimpeachable evidence of the phonograph, which is not yet generally recognized as a necessary part of the botanist's equipment. I regret that while I have been able to show pictures giving some idea of the obstacles to travel in the barrancas and lava beds, of the altogether tantalizing places in which choice plants are seen, and of the difficulties attending the transportation of those that can be reached, I have no phonographic record fit for public demonstration.

FIG. 22. WHERE CHOICE PLANTS ARE SEEN.

NOTES ON THE DEVELOPMENT OF TELEPHONE SERVICE. IV.

By FRED DELAND

VII. Some Early Telephone Switchboards

THE switchboards in the New Haven and other pioneer telephone exchanges were far more crude mechanically than the marvelous and sensitive hand telephone. The first switchboard that Mr. Coy installed in New Haven had a capacity of only eight lines, but as every line was a party-line, and as an average of twelve subscribers were on each line, the board served a hundred or more subscribers. This board was designed and built by Mr. Coy, in December, 1877, with the aid of a local carpenter, and formed a part of the partition

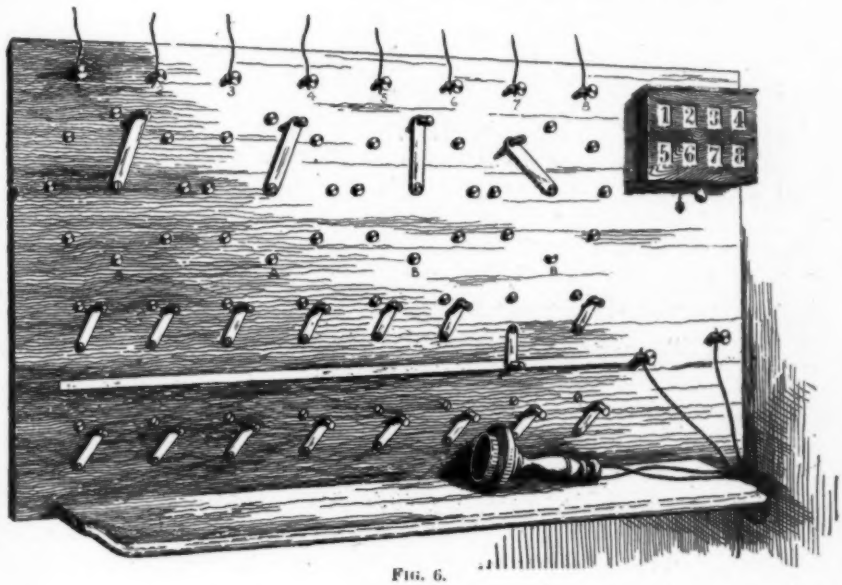

Fig. 6.

that separated the office from the battery-room. So far as known no photographs of the exchange or of the board were ever taken, and when the partition was removed the switchboard no longer existed. However, in Fig. 6 is an excellent reproduction of a rough sketch made from memory many years ago, of what Mr. Coy asserts was the first switchboard, though others claim that the board had no annunciator attached during the first two months.

Crude as the construction of the board was, without cords or plugs,

clearing-out drops or other improvements that facilitate rapid service on the part of the operator, it was considered a remarkable piece of workmanship in its day, and prospective investors in telephone systems traveled from various states to inspect Mr. Coy's equipment and to study the working method of this first of all telephone exchanges. The switchboard used in the Meriden exchange, opened a few days after the New Haven exchange, is now preserved in the Smithsonian Institution at Washington. It is similar in type to the New Haven board, and was designed by Mr. Coy. The switchboard used in Richmond, Va., as late as April, 1879, had six dials on its face, 'each circle about ten inches in diameter, formed by thirty-nine numbers.'

Service from Mr. Coy's board was supplied after the following fashion. On the shelf was a large induction coil with a manually operated buzzing attachment (Fig. 7). This calling device was known

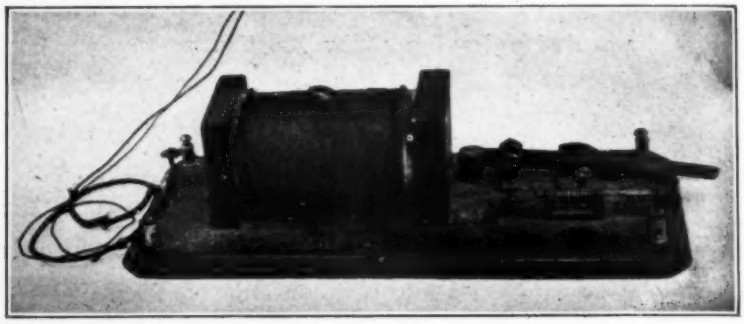

FIG. 7.

as 'Watson's squealer' and also as 'Coy's chicken,' for the shrill squeal it sent out over the line could be easily heard in all parts of a large room. When 'Central' desired to call a given subscriber on a party-line, as No. 5, for instance, on party-line No. 8, the operator connected this buzz-box to line No. 8 and sent five long squeals over the line, which would be the signal for subscriber No. 5 to come in on the line, and for the others to stay out.

For the use of his subscribers in New Haven, Mr. Coy hung the mahogany or rubber-encased hand telephone on a steel hook screwed into a black walnut board (Fig. 8) which he attached to the wall of the subscriber's room or office. Binding posts for wire connections were fastened to each corner of this board, with a simple strip type of lightning arrester connecting the upper two posts, line and ground. Near the center of this board and bridged on to the grounded iron telephone circuit, was a circuit-break push button for the subscriber to use in calling 'Central.' Below the push button was inscribed the number of the telephone.

Primitive as this outfit now appears, it was considered a luxury in 1878 that many were glad to have, and practically constituted the

entire telephone equipment supplied to subscribers by the early telephone exchanges. For as rapidly as other operating companies came into existence, they copied or adopted Mr. Coy's equipment, modified more or less according to the mechanical or artistic views of the local manager or his manufacturer. A modification used in Richmond, Va., is shown in Fig. 9.

In one sense these magneto systems might be properly termed central-energy exchanges. For though no batteries were required to operate these pioneer hand telephones, all the current required to signal 'central' or 'subscriber' was supplied from a 'common-battery'

FIG. 8.

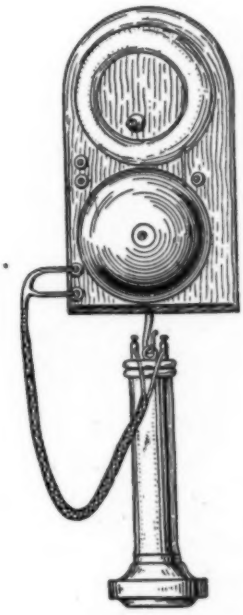

FIG. 9.

set of gravity cells maintained in the exchange and operating on a closed circuit.

When a subscriber desired 'Central,' he touched the metal push button, shown in Fig. 8, which actuated a single-stroke bell in the exchange and released a drop in the ordinary house-annunciator attached to the switchboard, thus indicating the respective party-line. On hearing the bell, the boy-operator would leave whatever other work he was engaged upon, walk leisurely over to the board, glance at the annunciator, turn the single switch to the metallic strip to bring his telephone in circuit with the calling subscriber, and loudly enquire: 'What do you want?' then place his telephone to his ear just too late to catch the full reply. Louder explanations on both sides would follow, and sometimes the subscriber's remarks were not of a character suitable

for publication, while the replies of the operator partook of the same lurid nature. For there were no sissy-boys and no girls among the pioneer operators of 1878–1880.

Finally, subscriber No. 5 would make the operator understand whom he desired to be connected with. Then the connection was given by turning the lever of one circle to the peg to which the calling-line was attached (Fig. 6), and placing the lever of the other circle on the peg or post connected to the line of the calling subscriber. The boy would then go back to his other work and probably forget all about the two subscriber-lines connected together, until an infuriated individual would rush into the office and demand the reason why some blithering idiot failed to answer his bell. Then the boy would have to pacify the subscriber as best he could by explaining that when two subscriber-lines were connected together, the call-bell and the battery-connection on each line were cut out to improve the talking qualities, and each subscriber was connected straight through to each other's telephone;

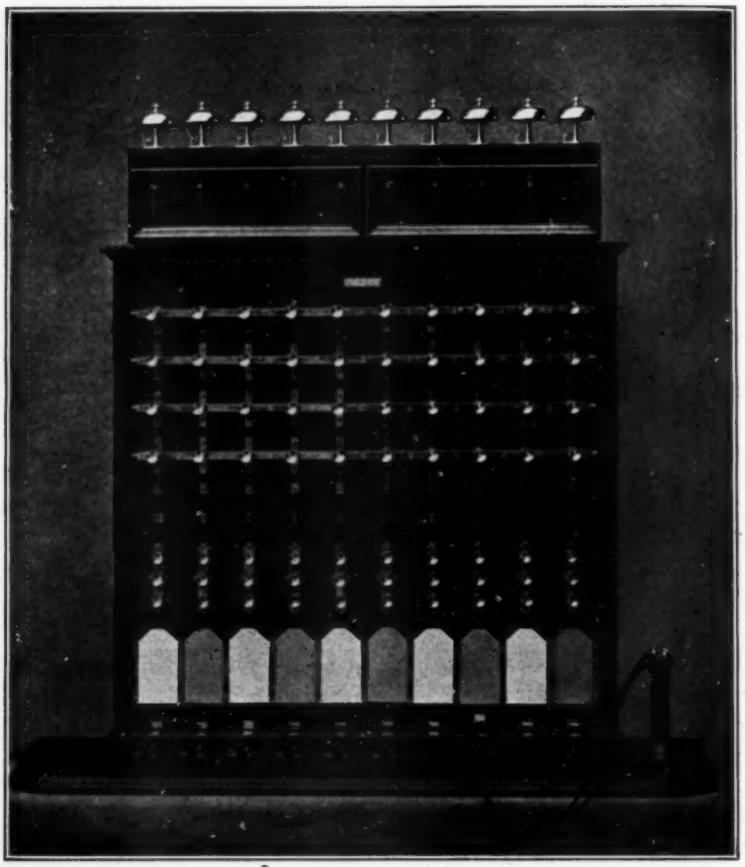

FIG. 10.

that in the pressure of cleaning batteries, or sweeping the room or doing some other kind of work, boy-like he forgot to disconnect the circuits.

With Mr. Coy's first board two telephonic connections only were possible at the same time. That is, two conversations only could be carried on at the same time. If a third subscriber desired connection, it was necessary to await the release of a lever by the disconnection of one of the other lines. Then the bright thought occurred to the boy-operator that by wetting the tips of his fingers and placing them on the respective pegs, his arms would become the levers of the respective circles, and thus the two subscribers could talk through his body. This very ingenious makeshift served to tide over the brief period during which an addition of two more circles was made to the original board, thus increasing its capacity fifty per cent. But one day, while the boy-operator was letting his wet finger-tips perform the service, now taken care of by cords and plugs, the ring-off signal came in from a subscriber who had just had a powerful magneto installed, and the shock received ended that very convenient practice.

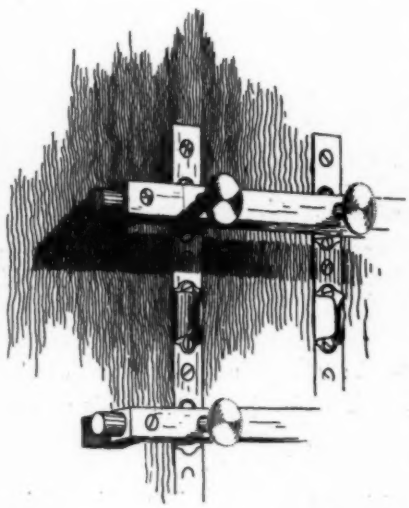

FIG. 11.

Soon there were more than 150 subscribers on twelve subscriber-lines, and the ratio of calls per subscriber was constantly on the increase. So a new board was planned by Mr. Coy and built by Mr. Snell, who is still in New Haven engaged in supplying equipment-specialties to telephone companies. This board (Fig. 10) had a line capacity of forty wires. Evidently switchboards of this type found favor for a time in the opinion of the parent company; for a circular issued in 1880, by the National Bell Telephone Company, contains the following suggestions, all of which were omitted from a circular of similar purport, issued a year later by the American Bell Telephone Company:

> There are several styles of switchboards that may be used, all depending on the general principles for their operation. They consist essentially of horizontal and vertical bars crossing one another and arranged so that any horizontal bar can be connected to any vertical bar. It is chiefly in the methods of making the connection that the various switches differ. In what is known as the 'plug' switch, the connection is made by inserting a small metal plug at the point where the horizontal and vertical bars cross one another. There are several forms of the plug switch. . . . In what is known as the slide central office switch, the connections are made by means of a sliding

contact plug, which can be moved on the vertical bars, and when placed over one of the horizontal bars, springs into firm contact with it . . . (as shown in Fig. 11). The brass rods for connecting any two lines together are fastened to the walnut frame, and in front of them but not touching, are the upright rods. The line circuits, as they enter the office, are connected to the upright rods by binding screws on top of the frame. Each of the upright rods has a spring-slide which, when pulled outward, can be slid freely on the rod, and which, on being released, springs into firm contact with any one of the horizontal rods with which it may be desired to connect it.

Within a year the increase in the number of subscriber-lines in the New Haven exchange made an additional board necessary. So a Snell board having a capacity for thirty-five subscriber-lines was in-

FIG. 12.

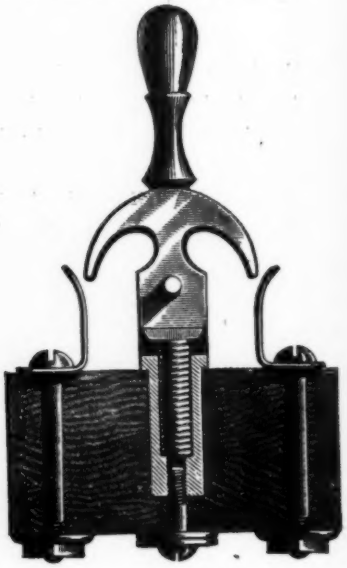

FIG. 13

stalled and connected to the old board. The principal feature of the Snell board (Fig. 12) is the Snell jack (Fig. 13). The instructions sent with the board read:

The line connects the levers together perpendicularly. The springs being connected horizontally, form the connecting bars. Any two circuits are connected by throwing the corresponding levers on the same row of springs. We have testimonials from parties using the switch, where one operator does all the work satisfactorily for *three hundred subscribers*, where with any other system it would require at least two, thus making a permanent saving in the running expenses.

A cheaper type of Snell switchboard is shown in Fig. 14, using what are called 'tip-up jacks.' This board consisted of an

inclined table, having as many grooves, about a quarter of an inch wide and deep, as may be required for connecting bars. Between every third groove is a row of counter-sunk holes for the wire posts inside of a spiral spring; a smaller wire passing through the ends of the posts forms the line and acts as a

hinge for the little tip-up jacks, that connect the line with the brass plate on the bottom of the groove. The spring allows the post to give a little, thereby making a rubbing connection and holding the jacks firmly in their place when any two are tipped up on the same groove to make connections.

The combined annunciator recording drop-plate shown on this Snell board is of interest in showing the appreciation in those pioneer days of the necessity of a measured-service system. Five falls of the plate (Fig. 14) would cause one revolution of the shaft, which, in turn, would move the indicating wheel one notch. A later form of switch-

FIG. 14.

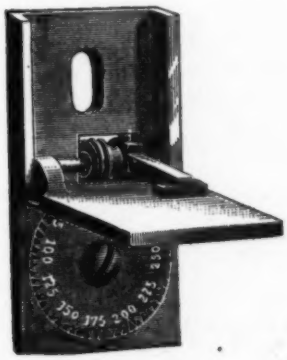

FIG. 15.

board devised by Coy and Snell is shown in Fig. 16. A board of this type was installed in Hartford in 1879. In December, 1881, in the Providence exchange there were thirteen Post-Snell switchboards of twenty-five wires each, four of fifty wires and one of sixty wires, arranged on three sides of the operating room, and from these eighteen boards service was supplied to eleven hundred subscribers.

The switchboards adopted by other exchanges were as unique in character as those erected in New Haven. In St. Louis, in April, 1878, Mr. George F. Durant used a 'jump jack switchboard,' the operation of which is thus described:

> On the subscriber ringing his bell, the annunciator would fall and the boy-operator would ask: 'What do you want?' Finding out what was wanted, the boy would notify the switchman what connection was desired, which was made by two single plugs attached to a single cord, by placing one of the plugs under each of the jacks requiring the connection.

The second switchboard had brass bars running the entire length of the board, with holes about every five or six inches to insert the plugs

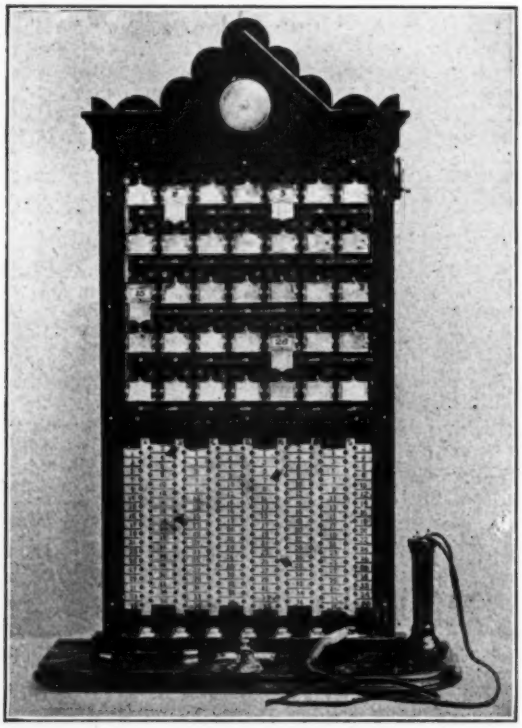

FIG. 16.

into, and were connected to the disconnecting switch through an indicator and jump jack.

In July, 1878, Thomas B. Doolittle planned and had constructed by Charles Williams, Jr., of Court Street, Boston, a twenty-circuit telephone switchboard, which Mr. Williams has stated 'was the first switchboard completely equipped with signaling apparatus ever made at my establishment.' This board (Fig. 17) was placed in Mr. Doolittle's exchange at Bridgeport, Connecticut, which succeeded to the first mutual telephone exchange system, and is the small board shown in Fig. 18.

In 1877, Mr. Doolittle had made a small six-point cross-bar switchboard for use in Bridgeport, in which he substituted simple switches for the usual telegraph plugs, as the former were more easily manipulated in making connections. Then he brought out the small board above referred to. Meanwhile he devised his 'direct-connecting board' (Fig. 18) in which each line terminated in the board after passing through a single stroke bell, to the hammer of which was attached a hollow brass ball suspended by a silk thread. To each circuit an operator's telephone was attached, and the cords were of sufficient length to reach the furthermost limit of the board. Following a subscriber's call the stroke of the bell set the brass ball to swinging, thus notifying

the operator, who cut off the battery by turning a switch and then inserted a plug in the line socket and received the call. The companion cord was then removed from the ground plate and inserted in the socket of the line called for. Mr. Doolittle states that on several occasions he saw the operator take care of four calls at the same time by holding two telephones in the fingers of each hand, that is, the operator had to talk and then listen into four separate telephones; in other words, using both ears as well as both hands. Incidentally it may be mentioned that Mr. Doolittle claims that it was on this board that the first female telephone operator was employed. A glance at the illustration shows that the cylindrical wooden weights suspended on the plug cords were about an inch in diameter and a foot in length, with a brass pulley attached to the top of each. These long weights were employed at first in anticipation that their length would prevent the cords from swinging and tangling, but later were displaced by smaller but heavier lead weights.

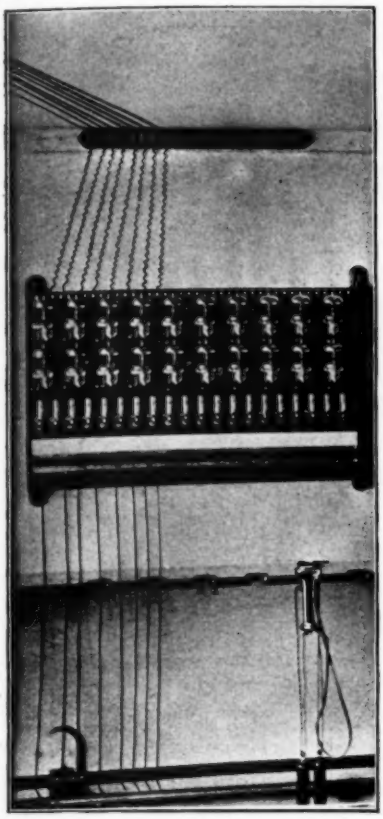

FIG. 17.

According to a local paper the switchboard erected in Philadelphia, in December, 1878, consisted of

> a walnut frame and braced strips of brass punctured with holes, into which wires are fitted to make the necessary connections. Behind this all the wires converging in the office concentrate. The board accommodates 400 different lines.

In October, 1878, the parent 'Bell Telephone Company' issued a circular describing a form of brass strip switchboard 'adapted for six circuits.' On February 20, 1879, a circular was issued describing a switchboard which could be supplied at

> from 50 cents to $1 per circuit, according to the number of circuits. The dimensions of this switchboard for from 50 to 200 circuits are 6 feet long by about 3 feet wide.

Switchboard tap-bells were listed at $2.50 each; subscriber's hook district bells, $3.25 each; spring keys, 75 cents each; lightning arresters, 37 cents per circuit. It was stated that "the following plan it is

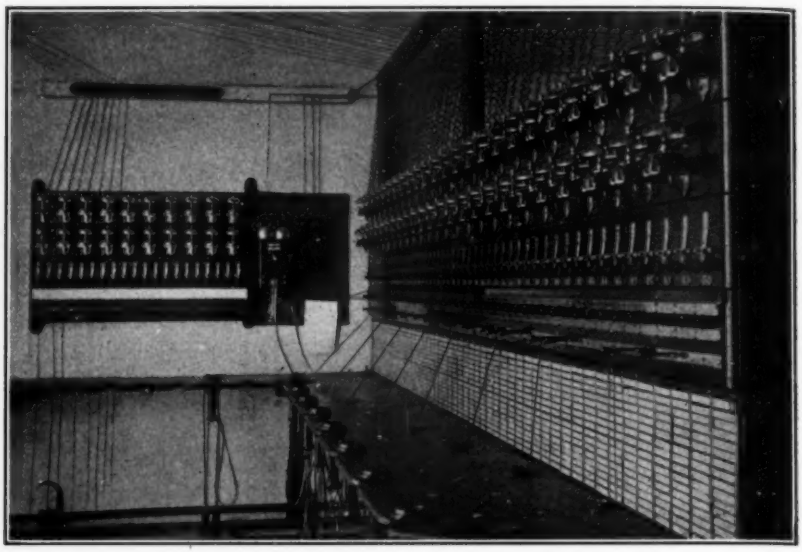

FIG. 18.

believed combines the advantages of the (thirteen) different systems." A diagrammatic representation of the wiring of a single circuit in this board is shown in Fig. 19. There is also shown a flexible cord attached to a plug and a wedge of hard wood having a metal plate fastened to one side. The instructions sent with the board read:

The local size gravity battery is used—one cell for each bell and for each mile of wire is sufficient. A circuit one mile long having ten bells requires about fourteen cells of battery. Two circuits may be operated by one battery if they are about equal length and have the same number of bells on each. . . . When any subscriber on this circuit wishes to call the central office he presses his knob twice, which rings the bell; the operator then inserts the wedge between the spring and the plate, with the metal side against the spring, and the plug into a brass strip which is connected through a set of telephones to the ground. This, it will be seen, takes off the battery and connects the telephones so that the operator can talk with the subscriber and ascertain his wants. If the subscriber wants to talk with a person on another circuit, the central office calls that person and on receiving his answer, the two circuits are connected together by inserting a wedge under each spring and putting each plug into one of a pair of brass strips which are connected together through a hand telephone by means of which the central office operator can ascertain when the two persons have finished using the circuits. Then he removes the wedges and plugs and the circuits are ready for another call.

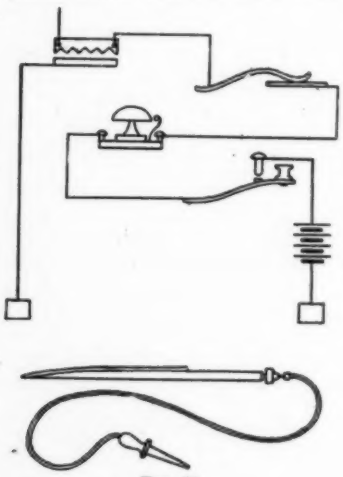

FIG. 19.

The instructions for the subscriber's equipment read:

The circuits are run from the central office and grounded at the last

stations. A small electric bell is placed in each subscriber's house or office, having a hook projecting from its base on which the hand telephone is hung when not in use (Fig. 20). When the telephone is removed this hook can be thrown either to the right or left. When thrown to the right the line wire on one side of the station is connected through the telephones to the ground and the line on the other side is opened, preventing any one on that side hearing what is said. When thrown to the left the reverse is true. It is obvious that no person between the two that are conversing can put his telephone in circuit without breaking the line, and consequently, interrupting the conversation. All other stations on the circuit are notified that the line is being used by the striker being away from the bell. In this case the subscriber must not attempt to call or use the telephone. The signaling is done by pressing and releasing a knob the requisite number of times. . . .

FIG. 20.

On June 12, 1879, the parent Bell company sent out photographs and a circular describing 'our No. 1 standard central office strip switch arranged for seventy-five circuits.'

In November, 1881, Mr. T. D. Lockwood said:

To make a good telephone exchange switchboard, however, out of an ordinary telegraph switch, we concede that considerable remodelling is necessary; and after the first heat of invention was over, practical men began to look about them, to see the disadvantages they were laboring under and endeavor to overcome them. It was seen that time and money were, in telephone offices, the two main articles to be economized. Time, because speed of connection is the very life-blood of the business. Money, because in many of the exchanges the telephone business was managed and owned by men of little or no capital; and, in others, the expense, in any case, would be great, and economy was necessary to make anything at all out of the business. Soon, therefore, it became obvious that the telephone switch must be compact; all the apparatus must be easily and quickly under control; everything about it must be well made and well put together; the motions required in a connection must be reduced to a minimum, and yet the apparatus must be cheap. The cry of cheapness for a long time obscured the vision of the practical man.

In 1881 came the first of the multiple switchboards. This innovation was arranged for grounded and later for metallic circuits, and was designed to eliminate many of the causes tending to slow down the service. Under the previous system each operator was compelled to act as information bureau, and subscribers called by name rather than by number. The introduction of the mutiple board made necessary the assignment of numbers to subscribers, and many an urgent request to call by number rather than by name. Thus the multiple-board operator made connections only in response to requests giving numbers. If complaints were made or information requested, the caller was quickly switched to the information desk presided over by a special operator. In the same manner the toll calls were handled at a toll

board or special section of the large board. A 1,500-line multiple switchboard was installed in New York in November, 1883.

In 1883 Mr. W. D. Sargent said:

The ideal (switchboard) system would be one in which the operator would receive the orders to connect and disconnect from the subscriber orally, by means of a head telephone; to have in front of her a switchboard by which she could connect any two wires of the whole system, however large, without interfering with the other operators. The nearest approach to this perfect system at the present time is the multiple-board; but this has never been worked on the true or multiple principle, and it can never show all its merits until it is. The multiple-board is now being introduced into many of the largest cities, and we may expect much information during the coming year on its merits.

Now-a-days a new switchboard is often placed in service so quietly that the subscribers are rarely aware of any change taking place until after the work is completed. But in the pioneer days it was somewhat different, as is shown in the following interview clipped from an eastern paper in 1882:

In removing from the old to the new central exchange unforeseen difficulties were encountered, chiefly in the removal of such a mess of wires and the abrupt change from the old system to the new system (of calling), and the

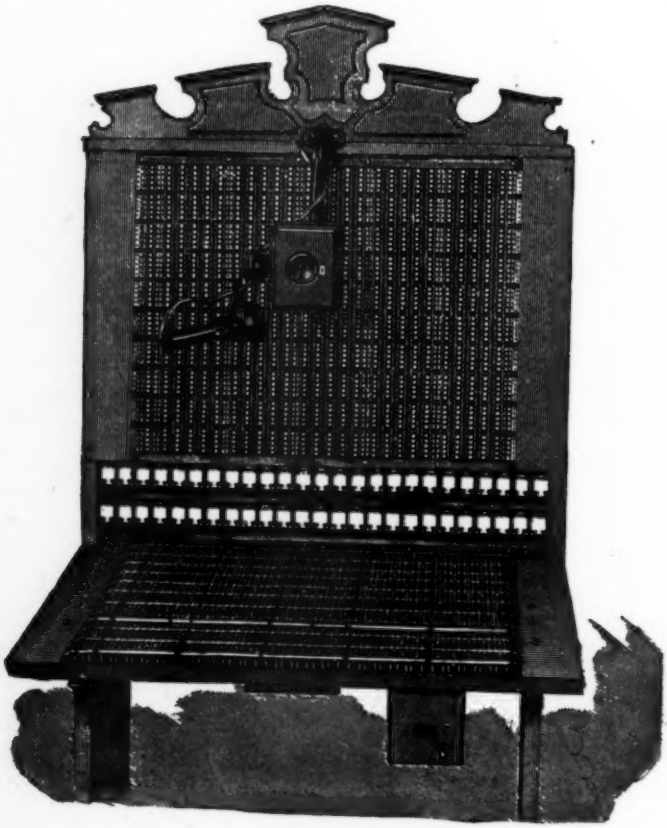

FIG. 21.

necessarily temporary character of much of the construction. The public had to be personally taught to use the new system, and our operators had to be educated in its rapid use. This naturally caused dissatisfaction, and before the system was tried and the construction trouble was eliminated, our subscribers, through misapprehension of the real purpose of the change, were invited to meet and form an association to protect their interests and compel satisfactory and perfect service on our part. . . . The association was soon compelled to acknowledge the superiority of the new service over that of the old.

In March, 1883, there were thirty Gilliland switchboards (Fig. 21) in the Pearl Street telephone exchange in Boston, and seventy-five toll lines terminated there. These boards stood about a foot apart and were displaced by a given number of multiple sections forming one compact, continuous board. In referring to the installation of the multiple switchboard in this exchange in 1884, Mr. Carty stated that

there were about 1,650 subscribers, ninety branch and thirty extra-territorial lines. The extra-territorial lines were handled by five operators on the 25-wire boards, on each of which there were a dozen or more subscribers. This called for a force of thirty-nine operators on tables at any one time, seven operators for relief and seven night operators, making a total force of fifty-three. With the multiple system only twenty operators are required to fill the boards in the main exchange, with five relief and four night operators. In the toll room, eleven operators are required, including the chief, one relief and two night operators. This makes a total of forty operators, handling 1,700 subscribers, 152 trunk lines, and shows a saving of thirteen operators.

Incidentally, it may be added that the Boston board was put in at an expense of $48,000. The old boards cost over $20,000, but brought less than one tenth that sum when sold as junk, though in use less than four years, and some less than two years.

In September, 1885, Mr. T. D. Lockwood suggested that where the multiple board was to be installed it would be well

to get the numbers drilled into the subscribers first. I was in Baltimore eighteen months ago, when the subscribers were all known by name. They were going to change that, and they were also introducing the multiple boards at the same time; and the operation of the new multiple boards was somewhat premature, because the old boards fell to pieces about a week before the new ones were expected and the change had to be made very quickly, and the change from names to numbers, and from the old board to the multiple board resulted in producing a condition of things very like a pandemonium for three or four days.

That the Western Union's competitive telephone service was of no better character than that of the Bell, notwithstanding its long experience in serving the public and the far greater resources at its command, is clearly portrayed in a description by a *Times* reporter, of a visit to the Chicago exchange of the American District Telegraph Company, in July, 1879. He wrote:

The racket is almost deafening. There are speaking tubes running all about the room, which look not unlike small stovepipes, and at one end and the other of these are placed the lips of one operator and the ear of another. Boys and girls are rushing madly hither and thither, seemingly without intent or direction; while others are putting in and taking out pegs from the metallic surface of the central framework or switchboard as if they were lunatics engaged in an old-fashioned game of fox and geese.

How different are present-day conditions in the large exchanges, where the operating force is well disciplined and thoroughly trained,

and where the modern relay multiple switchboard affords every facility for rapid intercommunication. So compact are these improved switchboards that each subscriber-line reappears in each and every section, thus enabling any one of the three operators allotted to a section to reach the jack connecting with the subscriber line of any one of the many subscribers connected to that given exchange even though they number ten thousand. Under these favorable conditions the average time in which 'Central' answers a calling subscriber rarely exceeds four seconds, and a local call is completed on an average of less than thirty-five seconds, the time consumed depending largely on the promptness with which the called subscriber responds to 'Central's' calling.

Concerning the rapidity with which telephone connections were secured in pioneer days, we have a statement made in 1887, by Mr. B. E. Sunny, a man of exceptional ability, who was one of the first to comprehend the true function of telephone service and who strove to make his service the best that human effort and improved apparatus could make it. Mr. Sunny said:

> Chicago has tried the division of labor plan on three distinct types of switchboard. On the first switchboard in the central office in about 1880, with four hundred subscribers, we were able to make a connection in about five minutes; on the second type of switchboard, which was the Gilliland, we were able to make connection with five operators in about two minutes. On the third type of switchboard, which was the Western Electric pattern, but of special make, we came mighty near not being able to make any connection at all; but after we had hammered away at it for a long time, we got the time down to about two minutes and a half. We changed from that to our present system of the unit of labor, and we make connections on an average of about forty-five seconds. So far as possible we make two operators on all connections, local and trunk, do the work.

It is also interesting to note that in 1884 Mr. Sunny started a school of instruction for telephone operators in Chicago. When an applicant appeared she was advised to enter this school and receive free instruction, and about one in four of the students were found competent to enter the regular service. When full, the class was composed of ten students. The teacher in charge was a former public school teacher, who had also served four years as an operator, monitor, chief operator, etc., under conditions that had enabled her to gain a thorough knowledge of the duties of an operator. The school apparatus consisted of three sections of switchboard and a dozen or more telephones connected up at different points in the school-room. Calls were sent in and connections made at the switchboards as nearly as possible according to regular practice. Mr. Sunny found that this method of training

> educates the students in the matter of hearing and talking and handling the cords and handling the cam-levers, so that when they sit down to actual work they have nothing to overcome except the momentary nervousness. In the old system we used to take a new-comer and put her on a section to answer fifty subscribers, and we used to depend upon the subscribers to educate the operator and make her competent to fill that position.

DENATURED ALCOHOL

By Professor S. LAWRENCE BIGELOW
UNIVERSITY OF MICHIGAN

WIDESPREAD interest was aroused by the passage, last June, of an act of congress permitting the manufacture and sale of alcohol tax-free after January 1, 1907, provided it be rendered unfit to drink by the addition of substances imparting to it a repulsive odor and taste. Such alcohol is known as denaturalized, denaturized, or denatured alcohol, and the substances added are called denaturizing or denaturing agents, or more simply, denaturants. These are barbarous terms, almost as repulsive as the substances themselves. It is only fair to add that neither Professor Matthews nor President Roosevelt is responsible for these dislocations of our language. They are literal translations from German and French equivalents. True to its resolutions of reform, our government has adopted the simplest of these terms and recent publications refer to denatured alcohol and denaturants.

The cause of the general interest in the subject is twofold. Each individual in the community has reason to think that he may perhaps derive some benefit from this bill; that he will be able to use denatured alcohol in a way to increase his comforts or to diminish his running expenses. A smaller number see in the new article of commerce possibilities of profitable occupation or of profitable investment. It is my purpose to consider certain facts regarding denatured alcohol which have a bearing upon these expectations.

Alcohol, to the chemist, is a class name for a large number of different compounds, all of which have certain definite characteristics in common. The proper name for 'ordinary alcohol,' sometimes called 'grain' alcohol, or 'spirits of wine,' constituting between 40 per cent. and 55 per cent. of the volume of whiskey, brandy and the other so-called spirituous liquors, 8 per cent. to 25 per cent. of the volume of wines, 3 per cent. to 8 per cent. of the volume of beers and ales, is ethyl alcohol. It contains only the elements carbon, hydrogen and oxygen. Its chemical formula is C_2H_5OH and it is the only 'alcohol' which can be taken as a beverage, all others being much more poisonous. For instance, wood alcohol, the correct name for which is methyl alcohol, a substance about which we shall have frequent occasion to speak as it is to be one of the denaturants, is closely related to ethyl alcohol, containing the same elements only in slightly different pro-

portions. This is clearly shown by its chemical formula, CH_3OH. But it is a dangerous poison, and numerous cases are on record of deaths due to its being mistaken for ethyl alcohol. This mistake occurs easily. A man asked a druggist for a bottle of good alcohol. The druggist understood him to say wood alcohol. The customer took his purchase home, drank it and died. Moreover, there is something particularly horrible about the action of wood alcohol. Numerous instances are on record proving that the substance has a specific effect on the optic nerve. After complete recovery from dangerous doses of methyl alcohol, in the course of a few days, patients have become totally blind. It is desirable that these facts should be as widely known as possible, since denatured alcohol is required by law to contain 10 per cent. of this poison.

It is not too much to say that if we arrange all the liquids known to us in the order of their general usefulness, water, which heads the list of course, will be followed immediately by ethyl alcohol. Ethyl alcohol is colorless and of an agreeable odor. It is an admirable cleaning agent, and a good antiseptic and disinfectant as well. It is an ideal source of heat and power and is capable of being developed into an ideal source of light. Ideal, because the products of its combustion, carbon dioxide and water, both of which are normally present in the air, are quite odorless and are harmless; ideal because, evaporating quickly and completely if spilled, it is much cleaner than any oil. It is an indispensable solvent in many chemical industries and is the raw material from which important substances, such as acetic acid (vinegar), the anesthetics ethyl ether and chloroform, the antiseptic iodoform, and many other substances are made. It is the cheapest and easiest of all the alcohols to manufacture.

Truly, it is unfortunate that to this list of advantages must be added the fact that it is drinkable, for this last property is made to justify so many restrictions that its application to these useful purposes is badly hampered. Alcoholic beverages are generally acknowledged to be unnecessary luxuries; therefore, by common consent, they are heavily taxed in every civilized country. A quantity of alcohol costing about 11 cents to make, namely, a 'proof' or 'tax' gallon, pays an internal revenue tax of $1.10. The 'proof' or 'tax' gallon contains about 50 per cent. by volume of ethyl alcohol, and about 50 per cent. water. The law reads in such a way that if the alcohol happens to be stronger, or above 'proof' as it is called, the number of gallons of 'proof' spirit which could be made from it is calculated and the tax is paid on this computed quantity. But, on the other hand, if the alcohol be weaker, *i. e.*, below 'proof,' it is taxed as if it were 'proof.'

This term 'proof spirit' had a somewhat curious origin which is

at the same time illustrative of the absurdly unscientific nature of many of our commercial units of measurement. Formerly, in England, a little pile of gunpowder was made and the 'spirit' to be tested was poured over this and lighted. If the burning alcohol, before going out, set fire to the powder it was said to be above proof; if it went out without igniting the powder, it was said to be below proof. Thus 'proof spirit' was defined as the most dilute alcohol which would set fire to gunpowder under these conditions. The ridiculous inaccuracy of such a test is sufficiently apparent. The British parliament and our congress both passed laws defining 'proof' in terms of specific gravity.[1] The alcohol which we buy for use in alcohol lamps or for

[1] "'Proof spirit' . . . was defined by act of Parliament to be such that at 51° F. (10° C.) thirteen volumes shall weigh the same as twelve volumes of distilled water. The 'proof spirit' so made will have a specific gravity of 0.91984 at 15.5° C. (60° F.) and contain, according to Townes, 49.24 per cent. by weight of alcohol and 50.76 per cent. of water. Spirits weaker than proof are described as U. P. (under proof), stronger than proof as O. P. (over proof); thus a spirit of fifty U. P. means fifty water and fifty proof spirit, while fifty O. P. means that the alcohol is of such strength that to every one hundred of the spirit fifty of water would have to be added to reduce it to proof strength."—'Handbook of Industrial Organic Chemistry,' by S. P. Sadler, p. 217.

"Proof spirit is alcohol of such a strength that 13 gallons of the spirit have the same weight as 12 gallons of distilled water at 10° C. Proof spirit contains 49.24 per cent. of absolute alcohol by weight."—'Outlines of Industrial Chemistry,' Thorpe, p. 409.

In the *Zeitschrift für angewandte Chemie*, Vol. I. (1888), p. 29, may be found tables for the conversion of per cents. over and per cents. under proof into per cent. of alcohol by volume. According to these, for instance,

1 per cent. over proof equals 57.8 per cent. alcohol by volume
70 per cent. over proof equals 97.3 per cent. alcohol by volume

that is, 100 per cent., or absolute alcohol, beyond which we can not go, corresponds to a little less than 75 over proof. According to these tables again,

1 per cent. under proof equals 56.6 per cent. alcohol by volume
70 per cent. under proof equals 17.2 per cent. alcohol by volume

that is, pure water, containing no alcohol, is 100 below proof. The above figures show 'proof spirit' as containing about 57.2 per cent. alcohol by volume.

The above definitions apply in England, but not in the United States. Section 3,249 of the Internal Revenue Laws in force January 1, 1900 (page 144) reads: "Proof spirit shall be held to be that alcoholic liquor which contains one half its volume of alcohol of a specific gravity of seven thousand nine hundred and thirty-nine ten thousandths (0.7939) at sixty degrees Fahrenheit."

The following dialogue appears in the hearings before the Committee on Ways and Means, February–March, 1906, on page 121:

Mr. Boutell: "In that connection will you kindly explain the use of the word 'proof' in connection with alcohol? Absolute alcohol would be what proof?"

Professor Wiley: "It would be 200. That is, a commercial gallon of pure alcohol would be 200 proof."

Mr. Boutell: "And a gallon of it on which a tax of a dollar and ten cents is levied is 100 proof?"

rub-downs is much stronger, averaging 85 per cent. or 90 per cent. Investigations carried out in Germany have demonstrated that the best strength for general, miscellaneous uses is 95 per cent. and that is the strength which we, as consumers, should insist upon.

It is readily figured out that such alcohol at the present time must pay a tax of $2.08 the measured gallon. The wholesale price is in the neighborhood of $2.50 per gallon, of which we may estimate the government gets $2.08, the distilleries 42 cents.

The tax on alcohol yields a not inconsiderable fraction of the whole revenue of the federal government. According to the 'Statistical Abstract' for 1904, published by the government, the Internal Revenue collections were as follows:

Year.	From Spirituous Liquors.	From Fermented Liquors.	Totals.
1900	$109,868,817	$73,550,755	$183,419,572
1901	116,027,980	75,669,908	191,697,888
1902	121,138,013	71,988,902	192,126,915
1903	131,953,472	47,547,856[2]	179,501,328
1904	135,810,015	49,083,458	184,893,473

The federal government has no disciplinary motive in this heavy tax; that function is performed by the individual states and cities under the familiar name of local option. The government merely takes advantage of the strong feelings of so many individuals against the use of alcoholic beverages at all to levy a tremendous tax. It is an interesting fact in this connection that no increase in the tax has ever produced an appreciable diminution in the amount consumed in this or in any other country.

The demands of manufacturers and others desiring to utilize alcohol for economic purposes were recognized long ago by other governments, and the efforts to satisfy these legitimate demands, while at

Professor Wiley: "Yes; it is called 'proof' simply. That means 100 proof."

Mr. Boutell: "It means one half of absolute alcohol and one half of H_2O?"

Professor Wiley: "Yes, that is what it means. This cologne spirit is about 96 per cent., and the rest of it is water. . . . This would be then 192 proof, or 92 above proof, as it is very commonly expressed. It is a purely arbitrary method of statement, fixed for the convenience of our excise office. When they say liquor is 'proof,' it means that it is one half ethyl alcohol and one half something else."

On page 154 of the same hearings:

Mr. Stevens: ". . . ordinary alcohol is 188 proof. You divide that by two and it gives you 94. You divide the proof by 2 and it gives you the percentage."

As Thorpe's and Sadler's books are so widely used as texts and as references, it is safe to assume that there is a little confusion as to the meaning of this term 'proof.' It should be made clear that there is this difference between the English and the American definitions.

[2] The war tax was removed from beer.

the same time safeguarding the revenues, resulted in this ingenious scheme of 'denaturing.' We are fifteen or twenty years behind Germany, France[3] and practically all other civilized countries with our recent measure. It is very evident, then, that there is nothing new about denatured alcohol. Our tardiness brings one advantage, however; we may profit by the experience of others. Some of this experience and some of the more important known facts may be considered conveniently under the three heads: the manufacture of alcohol; denaturants; and uses of denatured alcohol.

The Manufacture of Alcohol

The fact that alcohol results from the fermentation of sugar by means of yeast is well known. Cane or beet sugar, the chemical name for which is sucrose, is first broken up into a mixture of glucose and fructose. This mixture is known as invert-sugar, referring to optical properties which it would take too long to describe. This 'inversion' is produced by a substance called invertase present in the yeast. It may also be accomplished by the action of dilute acids. The glucose and fructose then undergo fermentation, a splitting up into ethyl alcohol and carbon dioxide, as a result of the growth of the yeast plant. Pasteur's long and brilliant investigations led him to believe that fermentation could never occur except when accompanying some kind of multiplication of cells, either yeast cells or bacteria, *i. e.*, some form of living protoplasm, and that it was thus a physiological phenomenon. By means of great pressures, Buchner, however, succeeded in extracting from yeast a liquid which contained no cells and no living protoplasm and yet produced fermentation. The German name for this liquid is *Presssaft,* which may be translated into 'press-fluid.' The fermentation is produced by a substance, which Buchner called zymase, in solution in this 'press-fluid.' Since then numerous other similar substances have been discovered which produce chemical changes, formerly supposed to occur only in conjunction with life processes. These substances, the inorganic or 'cell-less' ferments, of which invertase and zymase are typical, are known as enzymes. We really know very little about these enzymes or how they work, but they are intensely interesting and many of the ablest scientists of the times are engaged in their study.

Glucose and fructose are but two of a large number of chemically similar bodies which can be obtained from a great variety of agricultural products such as corn, rye, grains of all kinds, apples, grapes and fruits of all kinds, from Irish potatoes and from sweet potatoes, in short, from anything containing either starch or sugar. A list of

[3] In France, the first law relieving from taxes alcohol intended for industrial purposes was passed in 1814.

the names given to these substances would be superfluous; in the language of chemistry they are all sugars, though they are not all sweet. Differing in minor particulars, they all have certain properties in common, and the most characteristic of these common properties is that they each and all may be fermented and will yield ethyl alcohol as one of the products of the fermentation.

The methods for conducting the fermentation on an industrial scale have been carefully worked out, but it is not the intention to enter here into the details of that phase of the subject.[4]

Ethyl alcohol boils at a lower temperature than water, consequently when the dilute alcohol obtained by fermentation is subject to distillation the distillate contains more alcohol and less water than the original liquid. When the alcohol has been concentrated by distillation to about 40 per cent. or 50 per cent. of the total volume of liquid we have one of the so-called spirituous liquors—brandy, whiskey, gin or rum. These liquors owe their individual aromas and flavors to relatively insignificant traces of essential oils and organic esters derived from the particular material which was fermented. Just after they are made they also contain small quantities of distinctly deleterious substances (alcohols other than ethyl alcohol), which taken together are often referred to as fusel oil. These other alcohols should be removed before the liquor is put on the market. The old-fashioned way of removing them was to allow the crude liquor to remain for some years in oaken casks; the wood of the casks gradually absorbed some of the injurious ingredients, while others were oxidized by the action of the air and some coloring matter was extracted from the wood. Such a time-consuming process is not in harmony with modern methods, so we have numerous chemical processes for removing the undesirable constituents. We can impart what color we like with more or less burnt sugar and thus artificially 'age' our spirituous liquors and wines in short order. The number of patents allowed upon processes of this character is surprisingly large. A spirituous liquor is thus cheap stuff at the best, not worth intrinsically a tenth, often not a hundredth, part of its retail price.

The manufacture of whiskey, rum and the like, then, is really a step in the process of the manufacture of ethyl alcohol for commercial use. The alcohol, still too dilute, is subjected to another distillation; it is 'rectified.' This rectification is carried out with the assistance of an ingenious but simple contrivance with the somewhat pompous name of dephlegmator. A dephlegmator consists essentially of a series of chambers, one above the other, each succeeding chamber a

[4] For particulars see any one of the numerous excellent texts on the subject. Among the best are, 'Handbuch der Spiritusfabrikation,' by M. Maercker, eighth edition, and 'Practical Treatise on the Distillation and Rectification of Alcohol,' by W. T. Brannt.

little lower in temperature than the one beneath it. The alcohol vapor and water vapor from the still beneath pass through this dephlegmator, and it is readily seen that much of the water and some of the alcohol must condense in it and trickle back into the still. Inasmuch as alcohol condenses at a lower temperature than water it has the better chance to pass clear through, and into the condenser and receiver. Many modifications of this machine are on the market and they are all efficient. It is an easy matter, with it, to obtain 80 per cent. to 90 per cent. alcohol, and not difficult to obtain 95 per cent. alcohol. The last four or five per cent. of water clings hard to the alcohol and can not be removed by distillation alone. If it is desired to make yet purer alcohol, some substance such as lime, which combines eagerly with water, must be added to hold the water back, and then practically pure alcohol may be distilled off. Pure alcohol containing no water (100 per cent.) is known as absolute alcohol. But such pure alcohol is needed only for a few special chemical processes; there is no general demand for anything better than 95 per cent. Indeed, absolute alcohol has what may be called an avidity for water; it is hygroscopic, and if left in an open bottle will soon collect moisture out of the air and dilute itself.

It is evident that any distillery in the country—and there are about one thousand of them producing upwards of one hundred and fifty millions of 'tax gallons' a year—can increase its output to correspond to the demand which may spring up. The permission to market the product free of tax, if denatured, will then, in the first instance, merely furnish another outlet for the products of these distilleries. A new factory will find itself immediately in competition with the old established plants.

The question next arises, are there any methods of making alcohol other than those by which spirituous liquors are made? In the sense that spirituous liquors are essentially nothing but more or less dilute alcohol such other methods are obviously impossible. But there are methods starting with very different raw materials.

Berthelot, the French chemist, long ago showed how ethyl alcohol might be made synthetically from inorganic materials. The destructive distillation of coal gives us coal gas, and one of the constituents of this is ethylene. This ethylene will dissolve in sulphuric acid forming ethyl-sulphuric acid. If we add water and distil, ethyl alcohol is given off and collects in the receiver, while the sulphuric acid may be recovered in its original condition. At the present time we can start even farther back than Berthelot's starting point. A mixture of lime and charcoal heated in an electric furnace will give us calcium carbide. This calcium carbide, with water, will give us acetylene, and the acetylene will combine with hydrogen to form ethylene. Then the rest of

the process follows the outline laid down by Berthelot. This amounts to making our alcohol out of charcoal and water, and electrical energy derived from water power, with the assistance of some chemical reagents, which can be recovered and used over again. The process is simple and practical, but it costs considerably more to make alcohol this way than by fermentation, therefore there is no likelihood that installations on this plan will be put into operation yet awhile.

Now and then articles appear in the newspapers with such titles as 'Alcohol from Sawdust,' or 'Alcohol from Old Newspapers,' titles calculated to rouse the interest (perhaps the cupidity also) of readers, and conveying the impression that here at last is a new and brilliant discovery. There is nothing very new about it. Alcohol was first made from wood about one hundred years ago, and chemists have turned their attention sporadically to improving the methods ever since.

In round numbers 50 per cent. of the weight of wood is cellulose, a substance containing the same elements, in the same proportions by weight, as starch. Starch, under the influence of a suitable enzyme, or of a dilute acid, can be converted to fermentable sugar; and so can cellulose, although with greater difficulty and much less completely. Newspapers are made from wood pulp and are almost wholly cellulose. Many other things are largely cellulose, for instance, corn stalks, linen, hemp, flax, cotton (cotton wool is practically pure cellulose). From any of these ethyl alcohol may be made, indeed, Melsen of Brussels, as long ago as 1855, appears to have amused himself by seeing how long a list of substances he could compile from which he could say he had made ethyl alcohol.[5] His list included, besides those materials already mentioned, such things as dead leaves, stubble, straw, chaff, sweepings from malt, carrot tops, sponges, even birds' nests!

A complete history of all the partial successes would be tedious to any but professional chemists. The difficulty has always been, and still is, that only a small percentage of the cellulose present can be converted into fermentable sugar. This means that large quantities of material must be handled, large amounts of acids must be used, a great deal of fuel must be burned in heating these large quantities, and, after all, a relatively small amount of alcohol is obtained. If a weight of alcohol equal to 7 per cent. of the weight of the wood is secured, the yield must be considered good. Even this sounds promising because wood is cheap. But it should be understood that it is not the cost of the raw material which constitutes the obstacle; it is the cost of treatment.

Simonsen's and Classen's processes may be taken as illustrative of the best present methods for making ethyl alcohol from wood. They are being tried on a commercial scale in Germany.

[5] See Dingler's *Polytechnisches Journal*, Vol. 138, p. 426, 1856.

A large cylindrical vessel, of a capacity somewhat over 1,600 gallons, lined with lead which is not attacked by dilute sulphuric acid, is mounted in such a way that it may be revolved to agitate the contents. It is strongly built to resist considerable pressures. Such an instrument, whether large or small, intended for carrying out reactions under the combined influence of heat and pressure, is called an autoclave.

In Simonsen's process the autoclave is charged with 100 kilograms (220 lbs.) of sawdust and between 300 and 500 kilograms of dilute sulphuric acid (0.5 per cent. acid). Steam is blown in through openings in the axles until the whole has reached a temperature of 100° Centigrade (212° Fahr.), when the autoclave is closed. Then it is heated to about 175° Centigrade, the pressure in the interior simultaneously rising to about 135 lbs. per square inch. These conditions are maintained for about half an hour, while the contents are thoroughly stirred by rotation. The autoclave is then opened and the liquid is filtered off from the solid residue. A portion of the cellulose, under the influence of the acid, the heat and the pressure, has been converted to glucose, fermentable sugars, which are soluble and so are contained in the liquid, the filtrate. The solid residue is made up into briquettes for fuel. The acid in the filtrate is almost neutralized with lime (it is desirable to leave it feebly acid), and this necessitates another filtration, for the neutralization results in the formation of a solid precipitate of calcium sulphate which must be removed. Yeast, and a small amount of nutrient material for the yeast, are then added, and the whole is maintained at a temperature of 25° Centigrade for from three to five days. At the end of this time the fermentation is complete. The first distillation yields a 15 per cent. alcohol and a second distillation brings the concentration of the alcohol up to about 75 per cent.

Pine and fir wood give about the same quantities of alcohol, birch is better for the purpose. In a general way hard woods appear to give better results than soft woods. Seven liters of absolute alcohol from 100 kilograms of sawdust containing 20 per cent. of moisture must be considered a satisfactory yield.

Simonsen estimates that he can make 100 liters of absolute alcohol for 5.86 Marks, that is, at a cost of about 5½ cents a gallon. If this estimate were strictly correct, the process could compete with those based on the direct fermentation of agricultural produce; if it were strictly correct, it is reasonable to suppose that there would be more factories making alcohol from wood than there are.

Classen's process is similar to Simonsen's, but the chemistry of it appears to be more economical. Classen runs sulphur dioxide gas (which can be easily and cheaply obtained in any of the numerous

localities where there are deposits of iron pyrites) into the autoclave. The sulphur dioxide gas, under pressure, penetrates the pores of the wood, and uniting with the moisture there forms sulphurous acid, which serves the purpose of the more expensive sulphuric acid in Simonsen's process. When the autoclave is opened the excess of sulphurous acid gas is easily driven off and may be used on a fresh portion of wood. Furthermore, as less acid is left, less lime is required for the neutralization which must precede the fermentation. The claim is made that 25 gallons of absolute alcohol have been made from one long ton of sawdust by Classen's process.

Numerous modifications have been suggested, tried and patented, but this is not the place to enter upon a detailed account of these refinements. Perhaps the most interesting is the claim made by Gentzen and Roth in their patent that the addition of ozone, while the wood is being acted upon by acids and is under pressure, materially increases the amount of cellulose converted into dextrose, glucose and fermentable sugars.

The methods may be said to be on the verge of financial success and some small change or addition may any day convert a moderately profitable process into a brilliant success. Problems for physical chemists abound in these processes. We need to know exactly the most favorable concentration of acid, the best temperatures and pressures to be applied and the proper length of time during which the acid, heat and pressure should be allowed to act. Some work has been done on these questions and more is being done. For instance, it has been proved that prolonged action of the acid is harmful, for fermentable sugars which are formed early are later destroyed. It is therefore necessary to interrupt the process at the right time. Such experiments cost money and the time of highly educated men, and no one would dare to say positively that they would result in the discovery of a bonanza. Unfortunately, our manufacturers do not yet realize of what value truly scientific, highly trained, high-priced men would be to them, while the German manufacturers do, and so we may expect these, and almost all other such experiments, to be carried out, and the results to be obtained, in Germany. We shall get them after they have passed through the patent office and shall, very likely, soon be making large quantities of ethyl alcohol from wood, paying royalties to Germans for the privilege.

The suggestion has been made that a process for the manufacture of alcohol might be run profitably in conjunction with wood-pulp paper mills. There does not appear to be the least chance of utilizing the waste from the end of the sulphite process because it contains little or nothing fermentable. It has already been subjected for a long while to the action of sulphurous acid and the fermentable sugars, pro-

duced by a brief action of sulphurous acid on cellulose, have been destroyed again by the prolongation of the action.

But, in the manufacture of the pulp, the wood chips are often given a preliminary treatment to soften and partially disintegrate them. It seems perfectly possible that a liquor might be obtained at this stage of the manufacture which could be worked up into alcohol.

Denaturants

The properties which an ideal denaturant should have may be summed up under five heads and they are as follows:

1. It must render the alcohol undrinkable.

2. It must be cheap, otherwise the advantages of 'free' alcohol are lost.

3. It must be separable from the alcohol only with difficulty and at considerable cost.

It seems to the writer that government officials show a tendency to be more cautious than necessary regarding this feature of denaturing agents. Such a thing as a denaturant which a chemist could not remove probably does not exist, and so it is wholly a question of the degree of difficulty, and the cost, of the purification. If this difficulty and cost be never so little more than those involved in the manufacture of new alcohol from raw materials, it should be considered as fulfilling the requirements. Dishonest individuals, bent on swindling the government out of its revenues, would set up illicit stills rather than attempt to 'renature' denatured alcohol. But the government demands are much in excess of this standard.

4. It must be readily detected, in order that revenue officers may determine with ease whether a given liquid contains denatured alcohol or not.

5. It must not interfere with the use of the alcohol for those purposes permitted by law.

It is by no means easy to find substances fulfilling all these requirements; in fact, although the list of possibilities has been gone over and over again by the ablest living chemists for a matter of twenty years or more, the subject is by no means closed. All the denaturants tried and proposed are unsatisfactory in one way or another, and the governments of Russia, France and Germany offer prizes ranging from $4,000 to $20,000 for any denaturant which can be proved to be a distinct improvement over those in use.

Wood spirit, by which is meant, as has already been said, a crude methyl alcohol containing many impurities, notably in the neighborhood of 25 per cent. of acetone, obtained as one of the products of the dry distillation of wood, is one of the most satisfactory denaturing agents. It is difficult to remove from ethyl alcohol, it is readily de-

tected and it is fairly cheap. Alcohol, denatured by the addition of 10 per cent. of wood spirit and nothing else, has been on the market in England for years under the name of 'methylated spirit.' On the other hand, it does not impart to the alcohol such a repulsive odor and taste but what some perverts drink it if nothing else alcoholic is obtainable. According to the *Lancet* and other English papers, this terribly injurious habit has already reached alarming proportions and is on the increase. A penny will buy in 'methylated spirits' as much alcohol as is contained in a glass of whiskey.

One of the strong arguments brought forward in support of the 'free alcohol' measure was that methyl alcohol had been substituted in numerous industries where ethyl alcohol would have been better, and that the health of those obliged to work constantly in an atmosphere laden with the vapor of methyl alcohol was seriously impaired. The continuous inhalation of the vapor causes the same symptoms, in a milder degree, as those following the drinking of the alcohol, notably affections of the eyes. Those whose business it is to denature alcohol with wood spirits unavoidably labor under these disadvantages, but denatured alcohol containing 10 per cent. of the wood spirit will cause troubles of this character only under exceptional circumstances.

To make denatured alcohol yet less potable, German law requires the addition of a second substance, pyridine. The danger can not be wholly eliminated, as there have always been found at least a few so degenerate as to drink the most disgusting mixtures if only they contain alcohol. The so-called pyridine bases are obtained from the distillation of bones and also from tar. They constitute a somewhat oily liquid, soluble in both alcohol and in water, and they have such an utterly repulsive odor and taste that the addition of small quantities permits of the material reduction in the amount of 'wood spirit' used in denaturing. In Germany, alcohol is denatured by the addition of 2 per cent. of wood spirit and ½ of 1 per cent. of these pyridine bases.

But these pyridine bases have serious disadvantages also. They are volatile, and when denatured alcohol containing them is burnt in a spirit lamp the penetrating and highly unpleasant odor is perceptible in the room. They are combustible and should be wholly consumed, but when the lamp is blown out the parts about the wick remain warm and this heat volatilizes a portion of the liquid. If much of the vapor of pyridine be breathed it produces a severe headache, the same sort of seemingly unendurable pain which is produced by inhaling the vapor of nitro-glycerine. The injurious effect of pyridine on the health of those employed in denaturing alcohol has been the subject of discussions in the German Reichstag. The government of Germany permits the addition of small quantities of lavender oil to partially disguise

the detestable odor, and recently has permitted a reduction in the required amount of pyridine bases, substituting for it some benzine.[6] The experience of Germany indicates that pyridine, in spite of its disadvantages, is, on the whole, the best general denaturant known.

In Austria-Hungary the standard denaturant is practically the same as in Germany. In France it is much the same as in England—to 100 liters of alcohol are added 10 liters of wood spirit which must contain 25 per cent. of acetone and certain other impurities. Besides this, other substances must be added, the nature of the second substance varying according to the destination of the product. For instance, if the alcohol is to be used for heating, the addition must be half a liter of 'benzine'; if it is to be used for lighting, four per cent. of resin must be added.

We are to have our choice between the methods of France and of Germany. According to Regulations No. 30 of the United States Internal Revenue and to circulars Nos. 680 and 686 issued by the Treasury Department, alcohol may be denatured by adding to each hundred liters of alcohol of not less than 180° proof, ten liters of wood spirits and half a liter of benzine, or by adding to that quantity of the alcohol two liters of wood spirit and half a liter of pyridine bases. The wood spirit, benzine and pyridine bases, with which the denaturing is to be done, must be 'approved.' "The methyl alcohol submitted must be partially purified wood alcohol obtained by the destructive distillation of wood." "It must contain not more than 25 or less than 15 grams per 100 c.c. of acetone and other substances estimated as acetone." . . . "The benzine submitted for approval must be a hydrocarbon product derived either from petroleum or coal tar." "It must be of such character as to impart a decided odor to ethyl alcohol when mixt [*sic*] with it in the proportion of one half

[6] This word benzine is sadly overworked. Spelled with an *e*, benzene, it is the correct scientific name for a definite chemical compound of the composition represented by the formula C_6H_6. Spelled with an *i*, benzine or benzin, it is often used to mean benzene, toluene, xylene, mesitylene, or several other things obtained from the distillation of coal, or a mixture of any two or more of these things. More frequently it means any one of the score of substances obtained in the distillation of crude American petroleum before the temperature is high enough to drive off what we call kerosene. That is to say, it may mean rhigolene, cymogene, gasolene, or naphtha, petroleum-ether or ligroin, or a mixture of these. As these are themselves mixtures, the confusion is worse confounded. Many, if not most chemists, in an effort to avoid misunderstandings, adopted the German word benzol to indicate that definite and important compound C_6H_6, but the relief was for but a little while. Now benzol, too, has begun to be used in certain industries, as if it were synonymous with benzine or benzene. When one of these three words is used it is impossible to tell immediately what is meant; the meaning may be deducible later from the context, frequently it is not, as the chances are almost even that the speaker himself does not know. It covers a multitude of inaccuracies; perhaps that is why the word is so popular.

of one part by volume." The rest of the tests which must be applied and to which the denaturants must conform are not of general interest.

As the presence of denaturing agents prevents the use of the alcohol in numerous processes, other countries have long lists of substances used to partially denature alcohol destined for use in particular industries, partially protecting it, as it were, in transit from the factory in which it is made to that in which it is consumed. For instance, in France, alcohol intended for use in the manufacture of aniline dyes may be denatured by adding to 50 liters of the alcohol 50 liters of nitro-benzene or of nitro-toluene, and 10 grams of sodium hydroxide dissolved in 20 liters of alcohol. For varnishes, the product put on the market must contain 75 grams of resin per liter. There are in all about fifty different processes allowed for partial denaturing for as many special purposes. In Germany, for the manufacture of polish, alcohol may be denatured with one half of one per cent. of turpentine; for the manufacture of varnish, with 20 per cent. of a solution of one part shellac in two parts of alcohol; for the manufacture of the anesthetic, ethyl ether, and numerous other medicinal substances, with 10 per cent. of ethyl ether; for the manufacture of acetic acid, or vinegar, with 6 per cent. or 8 per cent. of acetic acid; for the manufacture of smokeless powders, 1 per cent. of camphor; and so on through a list as long as that in France.

Partially denatured alcohol never wholly leaves the watchful care of the guardians of the law. No list of partial denaturants permissible in this country has been determined upon. Interested parties are invited to make their suggestions and requests and these will be considered by the commissioner of internal revenue.

Uses of Denatured Alcohol

Every one knows from actual experience how clean and convenient spirit lamps are. There is never any soot nor smelly oil to be cleaned up, lamp chimneys remain clear and transparent and wicks require no trimming. The products of the combustion of ethyl alcohol are water and carbon dioxide, absolutely odorless and as harmless as any products of combustion can possibly be. It is much less inflammable than gasoline, and therefore safer. Water thrown on burning alcohol will immediately extinguish the fire, as alcohol is soluble in water in all proportions, while water thrown on burning oil or gasoline only makes matters worse. Oil and gasoline are lighter than water and are not soluble in it, so they float on top and continue to burn; throwing on water only spreads the fire.

Measured in terms of units of heat, calories, a given weight of ethyl alcohol is about twice as effective as an equal weight of petroleum. Its convenience, cleanliness, safety and adaptability to almost any sort of

burner in almost any place, is such that it would undoubtedly be preferred to all other fuels for all purposes if it were not for the cost.

The presence of any denaturing agent robs it, to a greater or a less extent, of some of its natural advantages. The odor of the denaturant is apt to be detected either before, during or after combustion.

Denatured alcohol has been found to dissolve some metals, notably brass. Of course the solvent effect is not rapid, but yet it is constantly under way and necessitates repairs to metallic lamps. The metal dissolves as a salt which is left on the wick when the more volatile alcohol burns, encrusting the wick and necessitating occasional cleaning or trimming. This crust interferes with the efficiency of the lamp whether it be used for heating or for light. But that is not the worst feature of the solution of metals in the alcohol. The small quantities of metal are in part volatilized and are deposited on any object which is being heated. Platinum crucibles are quickly ruined by this action and this alone is sufficient to absolutely prohibit the use of denatured alcohol in chemical laboratories.

Some investigations have been made to determine which constituent of denatured alcohol is responsible for this solvent action. Neither pure ethyl alcohol nor pure methyl alcohol nor pure pyridine, nor yet pure 'benzine' would dissolve metals. The most recent work appears to fix the blame on small quantities of organic esters, formed during fermentation and left in the alcohol itself, which of course is not so carefully purified, if it is to be denatured, as if it were intended for drinking purposes. This might appear to be a small detail, but is not, for it affects the usefulness of denatured alcohol for heat, light and power also. Anything corrosive in action could not be tolerated in the cylinder of an engine any more than it could in contact with a platinum crucible in the chemical laboratory.

The efficiency of a gas engine is the greater the greater the compression of the charge, the mixture of gas or vapor and air, before the explosion. Compression can not be carried far with gasoline, for compression, of course, heats gases, and gasoline catches fire so easily it is apt to explode prematurely, *i. e.*, while the piston head is traveling the wrong way. The fact that alcohol is less readily inflammable makes it possible to compress mixtures of air and alcohol much more without danger of premature ignition. Therefore a larger percentage of the power in alcohol can be utilized, it is more efficient. In parallel experiments Diesel obtained 17.6 per cent. of the power in kerosene as mechanical energy, 20.5 per cent. of the power in gasoline, and 31.7 per cent. of the power in ethyl alcohol. Those competent to judge say it will not be difficult to obtain 40 per cent. of the power in alcohol as mechanical work done. But, on the other hand, there is less power in alcohol than there is in the petroleum products, weight for weight, as

is shown by the relative heats of combustion to which reference has already been made. So that, at the present time, it is about an even thing between the two sources of power, weight for weight, with the chances good that American ingenuity will develop an alcohol motor superior to the gasoline motor.

Alcohol engines used abroad require a preliminary warming up before they will start. They are sometimes started with gasoline, and sometimes 25 per cent. of gasoline is added to the alcohol to cause it to ignite more readily. This may militate against alcohol as a motive power at the outset, but even now there are to be found in the current literature descriptions of alcohol engines which will start even without this brief preliminary warming.

Numerical data as to the consumption of alcohol per horse power are abundant. On the average, in small motors, the consumption at present may be taken at about one and a half pints of alcohol per brake horse-power hour. Professor Lucke, of Columbia, commissioned by the government, is now engaged upon a series of exhaustive tests of alcohol motors, and his results will be interesting.

Alcohol burns with a non-luminous flame. There are two general methods by which it may be made to furnish light. First, by adding some liquid, like 'benzine,' to it, which causes the flame to become luminous, and second, to utilize the heat to heat a mantle such as the ordinary Auer von Welsbach gas mantle, to incandescence.

A mixture consisting of 65 per cent. to 85 per cent. denatured alcohol and 35 per cent. to 15 per cent. of the distillate from coal tar, boiling between 150° and 160° Centigrade (mainly mesitylene) is on the market in Germany. It is known as 'Plehn's fluid' and burns with a luminous flame.

Before the discovery of mineral oil a mixture of ethyl alcohol and a very pure turpentine which was known as camphene[1] was largely used as an illuminant. It is of course possible to return to the customs of our grandfathers, but unfortunately the price of turpentine has risen enormously in the meanwhile.

On the whole the other method, burning alcohol with a non-luminous flame to heat a mantle on the plan of the Welsbach gaslight, is probably to be preferred to methods for making the flame itself luminous. It may be a little discouraging to prospective patentees in

[1] Camphene is another word almost as ambiguous as 'benzine.' Camphene is the correct scientific name for a definite chemical compound, a solid terpene of the formula $C_{10}H_{16}$. Turpentine is a mixture of pinene, also of the formula $C_{10}H_{16}$, but a liquid, and other similar substances; purified, it contains a higher per cent. of pinene, but is a mixture still, not pure pinene and certainly not camphene. This appropriation of scientific names by dealers to imply a higher degree of purity than actually exists in their wares is a constant source of confusion and a real hindrance to the dissemination of accurate knowledge.

this country to learn that lamps burning alcohol for light on this principle are to be numbered literally by the hundreds in Germany to-day. At a recent competition in that country for a prize for the best lamp no less than 99 new designs were entered.

These lamps are efficient, the best using only 16 to 20 cubic centimeters of 95 per cent. alcohol for ten hefner candle power hours. They are long lived, and will last without renewal of wick or mantle much longer than the ordinary incandescent electric lamp lasts. Not the least of their advantages in these days of domestic difficulties and problems is their extreme cleanliness.

The questions as to the efficiencies of the denatured alcohol lamps may be summed up by giving the results obtained by Professor Rousseau of Brussels. He has carried out many experiments and concludes that denatured alcohol at 31 cents a gallon furnishes a slightly cheaper light than kerosene at 15 cents a gallon.

But the subject is by no means closed. These alcohol lamps are slow in getting started and a minute or a minute and a half elapses after the match is applied before they are emitting their maximum light. This is because a portion of the alcohol must be vaporized before the heat is great enough to raise the mantle to full incandescence. This little detail is enough to condemn the lamps with many. That their imperfections are fully recognized is demonstrated by the fact that the government of France offers a prize of $10,000 for a device to burn alcohol under exactly the same conditions under which petroleum may be burned for lighting purposes. Similar prizes are also awaiting the fortunate inventor in Germany.

Questions involving the use of denatured alcohol in chemical industries must be omitted here, as anything like an adequate exposition would require much space. They are questions of great magnitude, involving perhaps the establishment of large and important manufactories.

In these as in all the uses of alcohol the presence of any denaturing agent whatever is at best a great nuisance. As was justly said by Professor Erdmann, of Halle, in a discussion of the subject, "It is most illogical and contrary to the most self-evident principles of economy to go to an expense in order to make a useful material less useful." But, as a recent newspaper editorial said, "It is one of the penalties which humanity as a whole must pay for the failings of a minority."

Costs and Prices

The cost of ethyl alcohol to the manufacturer is a subject upon which divergent opinions are held. It depends upon so many variable factors that it is doubtless different for each manufacturer, and moreover must differ from year to year if not from month to month. Cal-

culations as to what it should cost made from a given raw material by a certain process are apt to be misleading. Simonsen's calculation that a gallon of ethyl alcohol may be made from wood by his process for 5½ cents is an illustration of this. Results of experience on a commercial scale are more trustworthy.

Ethyl alcohol made from the molasses from sugar cane in Cuba and South American countries is sold at 10 cents a gallon. It takes about three gallons of this molasses to make one gallon of 100 per cent. alcohol. Assume that this molasses can be delivered at our seaports for 3 cents a gallon, and it is safe to say that alcohol can be made at those localities for 12 cents a gallon.

Evidence was taken by the Committee on Ways and Means before the passage of the present law and brought out many interesting facts. In a letter to the committee, Mr. M. N. Kline, referring to a distillery in Peoria, Illinois, said that alcohol had been made there, from corn, at a cost of 5.2 cents per proof gallon, and that the average cost during the last ten years was 10.78 cents per proof gallon. The low value corresponds to about 10 cents, the average value to about 20 cents per gallon of 95 per cent. alcohol. Before the same committee Mr. Batchelder estimated that with corn at 30 cents a bushel 90 per cent. alcohol could be made for 11 to 12 cents a gallon; with corn at 40 cents a bushel, for about 16 cents a gallon. He thought a fair price to distillers would be 20 cents a gallon. The concensus of opinion appears to be that corn is the most promising source of alcohol in this country, and the comparison, demonstrating the superiority of corn over potatoes, from which the bulk of the alcohol to be denatured is made in Germany, is carefully worked out by Dr. H. W. Wiley, of the Bureau of Agriculture, in recent *Farmers' Bulletins,* Nos. 268 and 269. In these bulletins Dr. Wiley also calls attention to the great possibilities of the cassava root as a raw material.

Secretary of Agriculture Wilson holds out very rosy prospects, and thinks it not impossible that alcohol may be made for three cents a gallon from corn cobs and from the juice of cornstalks at a certain period of their growth. Let us hope that Secretary Wilson's estimates may be justified by the events.

The retail price of 95 per cent. alcohol in Germany, converting the values to our units of volume and money, has been as low as 15 cents and at the present time is about 30 cents a gallon. That these prices do not always return satisfactory profits to the distillers is evident from an article published by Dr. E. Parow in the *Jahrbuch des Vereins der Spiritusfabrikanten in Deutschland* for 1906. After giving figures showing that there has been an overproduction of potatoes in Germany, because the increase in the demand for the products, alcohol and starch, has not kept pace with the increased crops,

he continues: "The old distilleries are still capable of existence to-day because they have moderately satisfactory established markets for their products, but more than this because they have in great measure already paid for themselves through sinking funds. New distilleries have not got this support. Money invested in them may be considered from the outset as lost. Hence one should advise as strongly as possible against the construction of new distilleries." Such pessimism as this is extreme, and German conditions are not American conditions. Still, at a time when we hear almost nothing but highly favorable accounts, it is perhaps well to call attention to the fact that there is another side to the question.

In the *Farmers' Bulletins,* already referred to, Dr. Wiley expresses the opinion that alcohol will not be sold in this country for less than 40 cents a gallon. Judging from the evidence given before the committee of congress and some of the other facts recited above, this price ought to furnish several eminently satisfactory profits. It may be hard to find any distiller of spirits ready to say that 20 cents a gallon is a fair price for his product, but it was, perhaps, easier to get close estimates before the passage of the bill than it is now that the bill has passed. It is to be hoped that the distillers will realize the danger that they may kill the goose, even before it has begun to lay golden eggs.

Much depends upon this question of price. So far as one can judge, alcohol at 35 or 40 cents a gallon will be upon even terms with kerosene at present prices for lighting purposes; even at a higher price it will be preferred by many on account of its cleanliness and safety. For the same reasons it may be preferred for running small motors about farms, for threshing machines, etc. At 20 cents a gallon it is about an even thing whether it will be chosen in preference to gasoline for automobiles.

On the other hand, the price of petroleum products may be lowered if the competition of alcohol becomes strong. Mr. Young of Michigan, in his speech opposing the passage of the bill,[8] said petroleum products could be bought in New York for 7 and a fraction cents a gallon by the barrel, and for 4 and a fraction cents a gallon in bulk. He also estimated the production of petroleum products in 1905 at the enormous quantity of 5,000 million gallons, and believes that the Standard Oil Company could sell for even less than 4 cents a gallon, if they thought it necessary, in order to retain their markets, and to drive out alcohol. Such figures make the prospects of denatured alcohol for heating and for power appear dubious.

In the hearings before the committee of Ways and Means it developed that in the northwest, for instance in North Dakota, petroleum

[8] See *Congressional Record*, Vol. 40, part 6, pp. 5317–5334.

products are high, while corn is cheap. Here, at least, denatured alcohol may be expected to displace gasoline. What applies to North Dakota applies equally well to many semi-isolated agricultural districts far from large markets, provided the alcohol can be made on the spot.

Whether or not the denatured alcohol business will become the property of a trust which will regulate prices is an interesting question. If the Standard Oil Company looks with such perfect equanimity at the advent of denatured alcohol upon the market, as Mr. Young attributes to it, it is strange rumors should so constantly appear in the newspapers that the Standard Oil Company is buying up the distilleries. These rumors might, indeed, be ascribed to the agitation in favor of the bill before it was passed, but this does not explain the persistence with which these rumors have been repeated during the last few months, since the passage of the act. The experience of other countries is worth noting in this connection. During the last year or so an alcohol trust has been formed in Spain, with headquarters at Madrid, and another was formed a year ago in Greece, with headquarters at Pyræus. Even one of the oldest of countries appears willing in these days to learn the tricks of trade from one of the youngest.

Any monopolization of the business of making alcohol would be totally impossible if nature were allowed to take its course. The process of manufacture is so simple and so readily carried out, and on a small scale requires so small a capital outlay, that groups of farmers could easily associate themselves and construct distilleries to convert their surplus crops into alcohol. Nearly every county in an agricultural district could have such a distillery and its products would find a ready market at home for light and power. The Commissioner of Internal Revenue, Mr. Yerkes, is reported to have been asked, some months ago, if there was anything in the free alcohol bill to prevent farmers and smaller merchants from so banding together; whether any provision of the bill would result in throwing the new industry into the hands of the distillers or of any other trust. He replied, 'Nothing whatever.'

A study of the rules and regulations which were issued September 29, 1906, to govern the manufacture, denaturing and sale of denatured alcohol, leads one to believe that he has supplied this omission; without a doubt unwillingly, and through a sense of his duty as custodian of the revenues, because Mr. Yerkes is well known to favor the 'free alcohol measure,' but none the less effectually. Such a labyrinthine web of restrictions and obstacles is surpassed in no other country or language, and is equaled only by the present United States Government restrictions on the distilling of spirituous liquors. It is more than

likely to deter any from endeavoring to make and sell denatured alcohol, except those who have already devoted a large share of a studious life to an endeavor to understand the present rules governing the distillation of spirituous liquors.

A few of these regulations are enough to give a fair idea of the whole 152 which require sixty-two good-sized, closely-printed pages for their statement. Any one desiring to denature alcohol must construct a bonded warehouse on the distillery premises. The most minute details of its construction are laid down, even to the make of locks used for locking the doors and securing the faucets and openings of the tanks. A room must be provided for an internal revenue officer whose duties appear to be largely to sit in the room and keep the keys in his pocket. "Not less than 300 wine gallons of alcohol can be withdrawn at one time for denaturing purposes." The denaturants after being approved must be kept locked in the bonded warehouse until used. Exact instructions concerning the bookkeeping of the establishment are given. The denaturants must be 'thoroly mixt' [*sic*] with the alcohol in the presence of a revenue officer. If no mistakes have been made thus far (and any mistake involves a stoppage of the process, the filling out of numerous legal blanks, and reference to an endless chain of supervisors, inspectors, collectors, and chemists), the manufacturer may draw off his product 'thru' his approved pipes and locks into receptacles of not less than 5 gallons, nor more than 135 gallons capacity, "all of which receptacles must be painted light green." Under no circumstances is a package containing denatured alcohol to be of any other color. It is to be hoped we may not be left too long in suspense as to the exact shade of green demanded for this momentous purpose. "Upon each head of the package shall be stenciled in red letters of not less than 1½ inches in length by 1 inch in width, the words, 'denatured alcohol.'" Seven other items of interest must be stenciled on the head, but probably through some oversight, the size and color of these letters do not appear to be specified. Complete transcripts of records of the previous month must be sworn to before the tenth of the next month. The form of affidavit is given, nothing seems to be forgotten, even the colors of the inks with which the records are to be written are prescribed.

Next follow regulations for the sale of denatured alcohol, if any one ventures into the precarious business of making it, undaunted by the legal pitfalls and penalties provided. 'Manufacturers of and dealers in beverages of any kind' are not permitted to keep nor store denatured alcohol; they are in danger of the strong arm of the law if they so much as have a light green cask with red letters on it in their possession. Druggists are mercifully exempt from this prohibition. Permits, which must be renewed each year, must be obtained before

any dealer can sell denatured alcohol. Apparently these permits cost nothing beyond the trouble of getting them, the filling out of forms, a few oaths, etc. Dealers must make monthly reports under oath of purchase, sale and stock on hand. All premises and all books of denaturers and of all dealers in or users of denatured alcohol must be open at all hours of the day and night to revenue agents and deputy collectors.

There is, of course, an equally elaborate system of safeguards covering the manufacture and use of partially denatured alcohol. If, in the course of a manufacturing process alcohol is used as a solvent and is recovered, it can not be redistilled except in the presence of a revenue agent. An almost overwhelming number of application forms, directions and prohibitions apply to this redistilling of recovered alcohol also.

It does not seem too much to say that the present rules about explode all hopes that small factories can be established in rural districts to convert an overproduction of potatoes, and the like, into fuel, a source of light, or a readily transported and marketable product. It does not seem too much to say that these rules inevitably throw the new industry into the hands of established distilleries, *i. e.*, into the hands of the whiskey trust.

A Standard Oil expert is quoted as reporting that denatured alcohol is not now in a position to rival petroleum products, but that it is a very favorable product to control. It is, indeed, a favorable product to control. Made by the growth of plants utilizing carbon dioxide and water from the atmosphere, it contains nothing but carbon, hydrogen and oxygen. All the rest of the plant may be returned to the soil, which thus is not impoverished. It is the best method known to us to-day to store the sun's energy. By its means the rotation of the seasons can be made to give an inexhaustible supply of light, power and heat. Some way should be found to safeguard our precious revenue, and at the same time to leave this valuable agent for the progress of civilization as free as the air, sunshine and rain from which it is made.

SPELLING REFORM AND THE CONSERVATION OF ENERGY

By Professor W. LE CONTE STEVENS
WASHINGTON AND LEE UNIVERSITY

THE basis of modern physical science is the conservation of energy. This doctrine, that the sum of the energy in our universe is constant while its modes of manifestation and transformation are indefinitely variable, has been established only within the last century, though vaguely foreshadowed many hundreds of years ago. Assuming the use of any machine for the transmission of energy, the amount of useful work done is less than the amount expended by the source because a part must be absorbed in the production and maintenance of motion in the machine itself, and in friction. With the development of heat and the radiation of this from the machine, energy that was initially available becomes transformed and ceases to be available. Such economic loss is physically a conservation.

The human brain is a machine for the transmission of energy, even though the work thus done may not be so readily measurable as that accomplished through the medium of a steam engine. The assimilation of food is the process by which energy from external sources is applied to the human machine and utilized through the medium of the brain. No physiologist has yet been able to analyze the mechanism of thought, but with the failure of the supply of carbon, hydrogen, oxygen and nitrogen, which in suitable combination constitutes food, the power of thought vanishes with the paralysis of the brain. The function of the educator is to guide and help young human beings to use to the best advantage every part of the human machine, and especially that part whose function is to originate ideas, to convey them by the use of suitable symbols, and to apply them for the benefit of the race.

The use of words for the oral conveyance of ideas, or of what are intended to be such, has always been the favorite occupation of more than a single sex. Every speaker acquires his own habits of expression that become recognized among his associates. A certain amount of what we familiarly call mental energy is put by him into the expression of an idea. Another output of such energy is expended by the hearer in the effort to take in that idea. Success is usually only partial, as every practical teacher will sorrowfully admit. Clearness of thought must precede clearness of expression, and this in turn must precede clearness of apprehension. The man's style may not be ornate, it may not be conventionally elegant, but it is good in proportion to his suc-

cess in conveying his ideas fully and accurately. In the process of transfer he has reduced the friction and the waste of inertia to the utmost. The least amount of work has been lost in the operation of two machines, the giving and the receiving, which form temporarily a connected system; and the active recipient's attention has been applied with good economy.

Men do not require to be highly civilized before the need is felt for the registration of ideas in addition to their oral transfer. Ideas are first symbolized, and the translation of such symbols into words soon suggests that words may be independently symbolized. The process continues until words are analyzed into their components, and these also are symbolized as letters. The art of spelling is thus born. But whatever the stage of symbolization, the written idea can never be more than an imperfect reproduction of the spoken idea, because symbols are arbitrary. The interpretation of a group of symbols is a synthetic process, and the opportunities for misunderstanding are fairly well proportioned to the complexity of the word machine employed.

The art of spelling is thus a development from early crude attempts to register spoken ideas and spoken words. The same word is often pronounced so differently by different speakers as to be scarcely recognizable. The English language when spoken by a highland Scotch or Welsh tongue to the ear of an American mountaineer fulfills quite well the dictum, commonly ascribed to Talleyrand, that the object of language is to conceal thought. From the very nature of the case spelling must vary as language varies. Orthodoxy may perhaps be as unchangeable as its representatives are prone to claim, but spelling has never been uniform, is not now uniform, and ought not to be more uniform than is the spoken language among the best educated scholars in great centers of population.

So long as literature was limited to manuscripts copied by professional scribes and seen only by the few who could read, and whose tastes prompted them to indulgence in such pleasure, spelling was as unsettled as forms of speech. The invention of printing not only produced a vast increase in the diffusion of reading matter, but tended to unify and give definiteness to the forms of symbolization. The railroad, the steamship, the telegraph and the printing press have been operated conjointly to bring all nations into closer communication than was ever foreshadowed by the optimistic dreams of our forefathers; but the adoption of a single language for the civilized world is still so far away in the future that no one gives the matter any serious consideration. Such unification is conceivable, but if ever approached it must be by gradual and almost imperceptible evolution, and not by prescription from any source, however scholarly and apparently authoritative. A new language, like Volapük, even though theoretically perfect, has not the ghost of a chance of adoption, because nobody is

willing to assume the labor of learning it or to use what would not be a practical means of communication.

And so it is with spelling reform. Men have been free to spell in any way that seemed best adapted to the reproduction of what they wanted to convey. Variety in speech has been as natural as variety in personal character, in dress or in amusement. Inconsistencies in fashion will continue as long as men retain their personal liberty to select idioms, words and spellings that suit the individual fancy of the user. So long as a babel of different languages continues on earth will there be a corresponding babel of spellings. There is no remedy but self-interest. In making ourselves understood we are compelled to recognize the conservation of energy. The man who writes a sentence must consider not only his own thought-machine but also that of his reader. Personal liberty to spell as a writer may find easiest or think best is soon limited by the necessity to make himself easily intelligible. If his spelling is very different from what has gradually become the fashion, the blunderer is soon made aware that he is hard to understand, and self-interest teaches him to avoid interposing obstacles between himself and his constituency.

The printing-press has been the great unifier in the establishment of fashion in spelling. But such fashion is not in the least sacred. In the spelling of the English language the fashion has been set for the most part in the printing office by foremen, or by mere type-setters who were entirely innocent of any hostile designs against orthography, etymology or logic. Professor Lounsbury has shown that the type-setting of the earlier books in our language was done mostly by printers who had come to England from the continent. In the city of Strasburg may be seen to-day a statue erected to the memory of Gutenberg, whose first crude invention of type was long unknown in England. Type-setting was initially and most naturally a German art, and it would have been very remarkable if the conservative and self-satisfied Englishman had been found ready to adopt promptly any art that had its origin outside of England. The intruding German or Dutchman could not be expected to possess much English scholarship, and in the printing room nobody could direct him because no directions for spelling existed even among the authors themselves. The Anglo-Saxon language had grown naturally and healthily. The English language was not then known to have any separate existence or special individuality. It later received a large infusion of Norman-French, and the thought of consistency, of uniformity in spelling or in anything else, had not occurred to anybody. Chaucer was limited by no orthographic conventions, and if his spelling could be improved by the Dutch printer his readers probably recognized the possibility that there might be room for improvement. It was not his fault if the improvement was confided to incompetent hands. His spelling was more consistent than that of to-day.

Such being the early development of our 'system' of English spelling, it requires a peculiarly religious spirit to discover in it anything sacred or worthy of special protection. The only protection that can be reasonably asked is the protection of the individual from the trouble of changing his habits, and this collectively means the protection of society from the confusion and general inconvenience that would result from sudden change of any kind if this could be effected by radical reformers. No language exists in which the spelling is even approximately phonetic. Italian, Spanish and German are among the most nearly exemplary tongues; but any one who studies German in America and then goes to Germany to spend a year or two, gradually discovers a good many words of which he has to change his pronunciation. The contrast, however, between German and English is conspicuous. It would be a waste of time to dilate upon the inconsistencies, the foolish freaks and stupid absurdities of English spelling and pronunciation. The facts are quite generally admitted by all who possess even an elementary knowledge of linguistics. The practical question is merely that propounded thirty-five years ago by a famous criminal, 'What are you going to do about it?'

Let it be granted that printers of various grades of ignorance during the last three or four centuries have accustomed the English-speaking public to the most inconsistent spelling with which any civilized people is loaded. All of us have spent months and years of early life in the effort to learn this spelling, not because there is anything educative about it, but because of the unwritten law that inability to spell 'correctly' is a sign of illiteracy. During the childhood of the present writer this idea was emphasized to such an extent that in the spelling class common words were of little interest. He was trained to feel a certain pride in his ability to spell promptly and unerringly such test words as gauge, hough, sough, fuchsia, bdellium, phthisical, eleemosynary, metempsychosis, and tragodididascalicological. The spelling match each week was a source of excitement, perhaps comparable in a small way with such modern dissipation as bridge or football. All of us have gone through this mill with varying grades of success so that our eyes have become accustomed to the absurdities, and our associations are violated when we look upon improved forms. It is easier to recognize 'though' than 'tho'; 'through' than 'thru'; 'kissed' than 'kist'; 'rhyme' than 'rime'; 'thoroughly' than 'thoroly.' Most persons think the improved forms unsightly. This means nothing except that they are unfamiliar.

To reform our language to such an extent as to make it logical and consistent is scarcely conceivable. Attempts to do so have been made on paper, but practically they have resulted in nothing better than rainbow chasing. Our alphabet is radically bad, having a superfluity of symbols for certain simple sounds, and no single symbols for

other elements of speech. Most of our vowels are sounded a variety of different ways, the most common ways being inconsistent with the sounds agreed upon in other modern languages. Spelling reformers have been agitating this matter for fifty years, but we are apparently no more ready to reform our alphabet now than when they began. Some of them, accepting the existence of an unchangeable alphabet, have persistently advocated the adoption of a strictly phonetic system of spelling; but, if they have made any practical progress outside of the volumes of proceedings of educational and philological conventions, it has been limited to the few enthusiasts who were willing to acquire the reputation of being peculiar and ill-balanced.

The movements in behalf of alphabetic reform and phonetic spelling have been made in complete disregard of the conservation of energy. The habits of the people must be recognized. A page of English printed in an amended alphabet is, to even intelligent persons, simply unreadable. It has to be slowly and painfully deciphered, like a page of Greek. It may, like Greek, be read if one will be patient enough, but the difficulties are crowded initially, and the man who is not a professional philologist exercises his right of choice and rejects what he finds bristling with difficulties. Let the page of English be printed now in ordinary type, but phonetically. The word 'physics,' for example, is spelled 'fizix.' This also, like Greek, may be deciphered, but the page will require a great waste of energy with no reward beyond the mastery of unnecessary difficulties. Let any business man conduct his correspondence for a single week in such style. His customers are immediately convinced that the object of language thus expressed is to conceal thought, and the pecuniary results may be readily inferred. Let a publisher put forth a new book in phonetic spelling. On neither side of the Atlantic would one reader in a hundred be found ready to buy it, or patient enough to read it if curiosity has prompted the purchase.

The recognition of these great obstacles to reform does not imply that whatever is, is right, or that reform is impossible. Let us assume that a cannon ball weighing half a ton is to be moved by a little child, using nothing stronger than cotton thread. It may be suspended by a steel chain from a support of known height, for example thirteen or fourteen feet, thus forming a big pendulum whose period is readily calculated to be about four seconds. Let the thread be attached to a hook on the side of the ball. A jerk from even a baby's hand is sufficient to snap it. But if a succession of gentle pulls be given at intervals of just four seconds, each too faint to break the thread, a few hours of such light work, patiently maintained, will be sufficient to make the pendulum swing through a perceptible arc. The advocates of alphabetic and phonetic reform have been jerking the thread, and they will continually fail to move the ball so long as they refuse to recognize its formidable inertia. People who are accustomed to bad habits,

whether relating to spelling or to anything else, need to be pulled gently, periodically and patiently. They are proof against argument, dictation, ridicule, legislation or physical force; but they will slowly yield if pulled in the right way and in the right succession.

However important may have been the influence of half-educated printers in the fastening of a hereditary spelling disease upon the users of the English language, the responsibility does not rest wholly upon them. Like other people, printers endeavor to adapt themselves to popular demands. The great classical schools of England have done much to infuse Latin and Greek into the language and to cultivate classical forms of spelling. Against the orthographic riot due to the early printers a reaction was inevitable. They gradually discarded many of the worst word forms that had been brought into use, but in the selection of surviving forms they had but small guidance from competent scholars. An approach toward uniformity was made, but it was under the domination of conservatism rather than reason or consistency, and popular habits were formed with no regard for simplicity or etymology. In the earlier English dictionaries by Bailey and Johnson very little was done to correct the prevailing inconsistencies. Johnson's great force of character made him a power among men. His knowledge of Latin was exceptional, but of etymology he knew little and cared less. As a lexicographer he was narrow, prejudiced and illogical. His dictionary was made the basis of Walker's dictionary, which in time attained wide currency on both sides of the Atlantic.

In all of these dictionaries it was apparently assumed that the function of the lexicographer is to record and define the words in current use, but not to search out or expose inconsistencies. The incongruities of our language make the dictionary more important as a reference book than it deserves to be. To this day multitudes of people accept without question what they find as allowed spelling in Webster or Worcester; and they resent any criticism upon what they consider to be established by the favorite standard.

What then are we to do about it?

The first and most important thing is to recognize the facts of human nature and the conservation of energy. This has been done by a small band of scholarly men, who have become incorporated during the year just ended as the Simplified Spelling Board, and to whom has been given the practical support of Andrew Carnegie and Theodore Roosevelt. This board recognizes the futility of trying to coerce the public, of trying to change the alphabet, of trying to secure immediate phonetic spelling, of advocating any radical changes, however desirable these may be theoretically. It has no intention of trying to set the pendulum into motion by breaking the thread. Its chief object is to attract the attention of the public to the history and present condition

of English spelling; to convince the public that fashion in spelling is not sacred; that our language is and ought to be a developing language; that development should be guided as far as possible toward simplicity and directness. It advocates the gradual approach to simplicity by neglecting useless letters in words commonly employed. It does not claim for itself authority to standardize our language, but seeks to get rid of the excrescences which make our language unreasonably difficult. It wishes to secure the establishment and extension of good usage, to make it national and international. It does not expect to escape the criticism of those who have learned to love the faults of our tongue, but only asks to be treated with fairness and not to be condemned for what it has never advocated.

As a first step the board has issued a now famous list of three hundred words which are commonly spelled in two or more ways, and it recommends the simplest of these spellings in every case. Many of the simple forms have already gained such currency in America as to be called Americanisms by our British cousins. Fifty years ago very few of them were current here, but their adoption has been steady, especially among business men, and their increasing popularity is based upon the American fondness for directness. On examining this list the present writer has found himself already habituated to the use of more than half of the simplified forms, though the more complex forms were all taught him in childhood. He is not conscious of having ever attained a local reputation for oddity in spelling. The changes in practise have been made gradually and to a large extent unconsciously. The remaining half of the list may perhaps become assimilated in due time, but no sudden change can be made now. It would be too inconvenient and difficult. As an advocate of simplified spelling he is unwilling to subject himself to an implied obligation to reverse old habits at once; but his mental attitude is that of approval and sympathy with a reform that is based on strong common sense. Inertia must be allowed for, and the pull on the pendulum must be properly timed.

President Roosevelt, Mr. Carnegie and the Simplified Spelling Board have been the objects of widely varying criticism. The greatest good they have done has been to focus public attention upon abuses which are of small concern to great people, but of great concern to small people. The little folks at school have no prejudices about orthographic propriety, and no burdens should be piled upon them merely for the sake of maintaining old blunders. An English critic of American ways considers it blasphemy to spell 'Savior' without a *u*. Let the English do as they find best; ours is the American language. Our declaration of independence will involve no bloodshed.

The opposition of Congress, and the consequent necessity for the withdrawal of President Roosevelt's executive order in behalf of simpli-

fied spelling, given to the public printer at Washington, was not a surprising development. The sudden adoption of two or three hundred changes at one time was too strong a jerk on the big congressional pendulum. But all these simplified forms will quite surely be incorporated in the great American dictionaries at an early day in their lists of alternative spellings. The public printer will thus be free to secure their gradual use in documents issued by the government. Readers of periodicals in which the simplified forms have already been in use, such as *The Literary Digest,* find no difficulty in taking in ideas, even if such forms as 'tho,' 'thru' and 'prest' are occasionally encountered. These periodicals are quietly doing effective work by dispelling the novelty of the improvements. In deference to public prejudice such forms as 'thru' are perhaps best neglected for the present, while 'tho' is used, since consistency is of little importance in comparison with tact. The Simplified Spelling Board can only recommend; the public will do the adopting in response to gentle and well-timed persuasion, and reasonable respect will be manifested toward the conservation of energy.

In conclusion the following propositions are presented by way of summary:

1. Inability to spell conventionally is not necessarily or deservedly an index of illiteracy.

2. Conventional spelling is a mere fashion, worthy of no respect when it implies the sacrifice of economy. In judging economy we must consider ease in the transfer of ideas. That spelling is best which is most readily intelligible.

3. Nobody can be reasonably expected to adopt more than a few changes at a time. A writer occupies himself with ideas rather than verbal forms. The simplified forms must be applied chiefly in the printing office, where forms are all-important. Change of habit must result chiefly from the unconscious training received by the eye in reading such simplified forms already in print.

4. Children should be taught simplified spelling. They will additionally learn the old conventional forms outside of the school-room, and should be free to exercise their own preferences so long as they are consistent in the employment of either system.

5. The simplification of our spelling does not imply the adoption of a new alphabet, or indulgence in objectionable phonetic eccentricities. All improvements are initially unfamiliar, and those who advocate them may be temporarily considered unfashionable, but reason in fashion has a better chance to prevail in America than in England, or in any other country where our common but necessarily variant language is spoken and written.

6. For the improvement of spelling there is always the need of moderate and practical reformers. The same slow process of change

that has been distinctly perceptible during the last half century may be expected to continue, but at a diminishing rate if nothing is done to accelerate it. All fashions tend toward fixity; and unless change is urged by those who are willing to appear at times a little odd, the old absurdities will for the most part continue indefinitely. The language is not going to change itself as a result of being proved inconsistent. No fashion is ever changed except by the exercise of personal initiative, but to secure change regard must be had for the difficulties experienced by the reader. The writer who adopts the simplified spelling has to be continually thinking of his spelling until new habits are formed, and his reader has to experience a succession of shocks that are at first irritating. The amount of friction in the complex thought machine is decidedly increased until it becomes worn smooth by such friction. Each advocate of improvement must use his own judgment as to the extent of his violation of conventional forms, but such violation must be perpetrated by him just so far as may be consistent with sane recognition of the conservation of energy.

FRITZ SCHAUDINN[1]

By Professor THOS. H. MONTGOMERY, Jr., Ph.D.
UNIVERSITY OF TEXAS

FROM the medical and biological world a genius has been taken, and it is not saying too much to conclude that the only man of the past half century who may be considered in any way the equal of Louis Pasteur is Fritz Schaudinn. Yet when Schaudinn died, on the twenty-second of last June, he was in only his thirty-fifth year. Truly those whom the gods love die young! The work of his life is so recent that only the perspective of time can throw it out in its true proportions; but rarely has it fallen to the lot of any man to receive the quick recognition of value that has been so generally conceded to Schaudinn.

With the exception of a few contributions on the worm *Ankylostomum*, on bear animalcules (*Tardigrades*), and on bacteria, the attention of Schaudinn was devoted entirely to the Protozoa; Dujardin, Max Schultze and Schaudinn, each of these marked a great advance in our knowledge of the unicellular animals, and of them Schaudinn covered the most difficult field. For his study of the Protozoa was an intensive examination of their complex life cycles, undertaken first to elucidate their genetic relationships and the meaning of alternation of generations, and second to break a road to the checking of human diseases. His discoveries are of fundamental importance for the understanding of the genesis of the cell, particularly of the phenomena of conjugation and the reduction of the chromosomes, for our ideas of the genetic relations of the various Protozoan groups, and for the prevention of disease. It may be said that before Schaudinn entered the field almost all human infectious diseases were supposed to be due to bacteria, with the exception of the malaria parasite and certain few agents doubtfully associated with unimportant disorders. To Schaudinn more than to any other belongs the credit of the demonstration that the Protozoa are fully as efficient as the bacteria in transmitting and engendering disease. Indeed, the greatest advance in medicine of the past twenty years may be said to be just this conclusion. Schaudinn's particular merit lies in his insistence that the first step in combating any disease must be to understand the whole life cycle of the disease germ; and his genius, in his admirable and unequaled success

[1] Contributions from the Zoological Laboratory of the University of Texas, No. 83.

in solving each complex life cycle that he undertook to investigate. All his discoveries were comprehensive and thorough, they settled the particular questions examined, and this though he selected problems the most difficult of solution. By all his training he was a zoologist, and he is a splendid instance of the fact that comprehensive results in medicine are possible only to him who has a broad biological foundation on which to build. The study of human disease is to be successful not so much by close study of human parasites only, but rather by investigation, through broad comparisons, of the animal and plant groups to which the parasites belong; in that method only is surety given.

For two years it was my privilege to work in the same room with Schaudinn as a fellow student, in the Zoologisches Institut at Berlin; accordingly, this little account of his life is as much the message of a friend as of an admirer. Of the group of students at that laboratory from 1891 on, Schaudinn was the leader from his great and rare natural modesty, as well as from his forceful character and power of tremendous application. With regard to the latter quality I well recall how on one occasion, while with exquisite ardor he was following the stages of a life cycle, he spent more than thirty uninterrupted hours at his microscope. With all his humor, his hearty laugh and his popularity, he rarely spent an evening at the Weinstube or the Bierhalle, but for his recreation took long walks into the countryside, showing a delight in every phase of nature. Perhaps the chief secret of his success was his almost intuitive ability to select the important phenomenon from the less important, and to focus his mind on that; he never allowed himself to become bewildered by the multitude of the facts, truly a rare gift.

Immediately after his death there appeared an appreciative account of his life by his old teacher, Professor Karl Heider, of Innsbrück; then a second by Professor Gary N. Calkins, of Columbia University, this printed in *Science;* and within the past two months more detailed biographical accounts by Professor Richard Hertwig, of Munich, and F. W. Winter, of Frankfurt-am-Main. The last named is the most complete yet given, and was published in the *Zoologischer Anzeiger,* November 13; it gives a careful analysis of his various papers and labors, together with a complete bibliography.

Fritz Richard Schaudinn was born in Röseningken in East Prussia in 1871. In the laboratory of F. E. Schulze in Berlin he commenced his investigations on Protozoa in 1892. His first years there were devoted to the investigation of free-living species, both freshwater and marine, and the rhizopods in particular. Before he made his doctorate he settled a long controversy by demonstrating that the two forms of many-chambered foraminifera, those with a large and those with a

small embryonal chamber, represent different stages in the same life history. He elucidated the life cycle of *Calcituba,* and discovered in it a simple and probably very primitive mode of cell division. The division of the *Amœba* with two nuclei (*Amœba binucleata*) was described, and from Schaudinn dates the concept that the original cell possessed two nuclei. Then he described the copulation of the Heliozoan *Actinophrys,* which was the first account of reduction of the chromatin and caryogamy of any protozoan, compared the processes here with the similar ones in the many-celled animals, and showed that the central granule acted as a centrosome. Conjugation of the spores was also discovered in *Hyalopus,* a foraminiferan; and his discovery of the paranucleus of *Paramœba* has come to greatly modify the older ideas on the genesis of the cell nucleus. These discoveries rapidly succeeded each other, marked a great advance over all preceding studies on the reproduction phenomena of the protozoa, and stimulated others to the same field of study.

Next he turned himself to the analysis of the life cycles of parasitic protozoa, a study of particular difficulty because all such parasites live in successive different hosts. Most men have failed in these studies because they lacked the fertility and resource of Schaudinn in devising experiments. Monumental was his study on the complete life cycle of a coccidian (a sporozoan), a parasite of a centipede (*Lithobius*), made in conjunction with Siedlecki. This gave for the first time the complete history of any sporozoan, and was soon followed by an equally conclusive and thorough research, extending through five years, of the life cycle of *Trichosphærium.* These are classics in the study of the protozoa, and they showed the method by which results are to be reached in the search of the parasites of human disorders. In each of these life cycles there follow upon each other a long line of generations, with great dissimilarity of the successive generations; Schaudinn drove home the conclusion that the unit of study should be the whole life cycle, and his results rendered it probable that many forms of protozoa that had hitherto been regarded as different species might be merely stages of one and the same life cycle. This was one of his major contributions that guided him in his later work and has caused an entire change in progressive medicine.

Schaudinn then left Berlin to become director of the laboratory at Rovigno, on the Adriatic Sea, whither he was called primarily to contribute to the study of the malaria organisms. There he first worked out the life history of *Cyclospora,* the agent of enteritis of the mole, carrying out his method to approach human disorders from a preliminary broad comparative basis. Then he made a valuable contribution to the history of *Plasmodium vivax,* the cause of tertian fever in man; and was the first to see the sporozoites entering living human

blood corpuscles. The sanitary recommendations then recommended by him against malaria were adopted by the Austrian government. Further, he made observations on the biology of the mosquito that carries these protozoa. Then he worked out a blood parasite of the lizard, and discovered a Rhizopod, *Leydenia,* in the ascites fluid of man.

His next step was to study the parasites of the human colon, which had been called *Amœba coli.* Schaudinn discovered that this really is two distinct species, one of which is harmless, while the other, *Entamœba histolytica,* he proved to be the cause of human bloody dysentery.

His following contributions were devoted to the study of blood parasites, so-called hæmosphoridia. His initial memoir upon this subject was one of his most important. He studied the three blood-parasites of the owl, known as *Proteosoma, Halteridium* and *Hæmamœba,* which he proved to be stages of one and the same life cycle and to be flagellates and not sporozoa. Here also may be mentioned his conclusion that the organisms of human malaria are also flagellates. In connection with this study he worked out the biology of the mosquito (*Culex pipiens*) that infects the owl, and its mode of transference of the parasites. In his investigation of *Spirochæte ziemanni* he made the important discovery that the two main forms of blood flagellates, *Spirochæte* and *Trypanosoma,* are not bacteria, but flagellates, a discovery that has wonderfully clarified our knowledge of blood diseases.

In 1904 Schaudinn left Rovigno to enter the National Sanitary Commission at Berlin. He was fully recognized as the foremost investigator of Protozoan diseases, and though he had never studied medicine he became its consultant authority in Germany. Unwisely the German government for a time placed hindrances to his free initiative, and forced him to undertake certain work outside of his proper field; he had no choice but to accept these conditions, for he was a poor man with a family to support. Principles of patriotism decided him to decline a call to the professorship of protozoology recently started by the British government for the investigation of tropical diseases. At this time Schaudinn corroborated the interesting discovery of Looss, that the round worm *Ankylostomum* infects the mammalian host not through the mouth, but by entering the skin then being transported by the blood current to the lung, and thence to the intestine.

Perhaps what is the most important medical discovery made by him was that of 1905, when he found in the secretions of syphilitic growths a parasitic flagellate that he named *Spirochæte pallida.* Long had physicians searched for the cause of this disease, one of the most widespread and terrible of human disorders, and it was the crowning act of Schaudinn's life to have found it.

Early in 1906 Schaudinn was appointed zoologist to the Institute for Ship and Tropical Diseases at Hamburg, a position that he gladly accepted, because it gave him perfect freedom for his studies and for the first time in his career an income that freed him from financial cares. But within a few months he fell a victim to intestinal abscesses, from which he had suffered for years and which he may have contracted through infection during his studies on the protozoa of the human intestine.

Most of Schaudinn's memoirs were briefly and concisely written, for he disliked to take time from his observations to put it on writing. As Richard Hertwig says of him, 'he was not a man of the writing table.' With his death, accordingly, as in the case of other great men, many of his important results have been lost to science. His descriptions are remarkable for their lucidity, as his experiments for their simplicity.

He was essentially a phylogenist, an investigator of racial history by the analysis of individual life cycles, and his achievements furnish the best possible evidence of the fruitfulness of phylogenetic study. He never called in to his aid hypothetical units, but each and every step in his conclusions was based directly upon empirical evidence; he was not a theorist, but a demonstrator. Cytology has to thank him for tracing the genesis of the centrosome, of chromosome reduction and conjugation; biology in general for demonstrating the necessity of considering the life cycle as a unit, and for having so greatly extended our knowledge of life cycles; medicine recognizes his lasting influence in the study of malaria, as the discoverer of the disease germs of dysentery and syphilis, and for pointing out the methods to follow in the study of protozoan disorders.

THE VALUE OF SCIENCE

By M. H. POINCARÉ
MEMBER OF THE INSTITUTE OF FRANCE

Chapter VI. *Astronomy.*

GOVERNMENTS and parliaments must find that astronomy is one of the sciences which cost most dear: the least instrument costs hundreds of thousands of dollars, the least observatory costs millions; each eclipse carries with it supplementary appropriations. And all that for stars which are so far away, which are complete strangers to our electoral contests, and in all probability will never take any part in them. It must be that our politicians have retained a remnant of idealism, a vague instinct for what is grand; truly, I think they have been calumniated; they should be encouraged and shown that this instinct does not deceive them, that they are not dupes of that idealism.

We might indeed speak to them of navigation, of which no one can underestimate the importance, and which has need of astronomy. But this would be to take the question by its smaller side.

Astronomy is useful because it raises us above ourselves; it is useful because it is grand; that is what we should say. It shows us how small is man's body, how great his mind, since his intelligence can embrace the whole of this dazzling immensity, where his body is only an obscure point, and enjoy its silent harmony. Thus we attain the consciousness of our power, and this is something which can not cost too dear, since this consciousness makes us mightier.

But what I should wish before all to show is, to what point astronomy has facilitated the work of the other sciences, more directly useful, since it has given us a soul capable of comprehending nature.

Think how diminished humanity would be if, under heavens constantly overclouded, as Jupiter's must be, it had forever remained ignorant of the stars. Do you think that in such a world we should be what we are? I know well that under this somber vault we should have been deprived of the light of the sun, necessary to organisms like those which inhabit the earth. But if you please, we shall assume that these clouds are phosphorescent and emit a soft and constant light. Since we are making hypotheses, another will cost no more. Well! I repeat my question: Do you think that in such a world we should be what we are?

The stars send us not only that visible and gross light which strikes our bodily eyes, but from them also comes to us a light far more subtle, which illuminates our minds and whose effects I shall try to show you. You know what man was on the earth some thousands of years ago, and what he is to-day. Isolated amidst a nature where everything was a mystery to him, terrified at each unexpected manifestation of incomprehensible forces, he was incapable of seeing in the conduct of the universe anything but caprice; he attributed all phenomena to the action of a multitude of little genii, fantastic and exacting, and to act on the world he sought to conciliate them by means analogous to those employed to gain the good graces of a minister or a deputy. Even his failures did not enlighten him, any more than to-day a beggar refused is discouraged to the point of ceasing to beg.

To-day we no longer beg of nature; we command her, because we have discovered certain of her secrets and shall discover others each day. We command her in the name of laws she can not challenge because they are hers; these laws we do not madly ask her to change, we are the first to submit to them. Nature can only be governed by obeying her.

What a change must our souls have undergone to pass from the one state to the other! Does any one believe that, without the lessons of the stars, under the heavens perpetually overclouded that I have just supposed, they would have changed so quickly? Would the metamorphosis have been possible, or at least would it not have been much slower?

And first of all, astronomy it is which taught that there are laws. The Chaldeans, who were the first to observe the heavens with some attention, saw that this multitude of luminous points is not a confused crowd wandering at random, but rather a disciplined army. Doubtless the rules of this discipline escaped them, but the harmonious spectacle of the starry night sufficed to give them the impression of regularity, and that was in itself already a great thing. Besides, these rules were discerned by Hipparchus, Ptolemy, Copernicus, Kepler, one after another, and finally, it is needless to recall that Newton it was who enunciated the oldest, the most precise, the most simple, the most general of all natural laws.

And then, taught by this example, we have seen our little terrestrial world better and, under the apparent disorder, there also we have found again the harmony that the study of the heavens had revealed to us. It also is regular, it also obeys immutable laws, but they are more complicated, in apparent conflict one with another, and an eye untrained by other sights would have seen there only chaos and the reign of chance or caprice. If we had not known

the stars, some bold spirits might perhaps have sought to foresee physical phenomena; but their failures would have been frequent, and they would have excited only the derision of the vulgar; do we not see, that even in our day the meteorologists sometimes deceive themselves, and that certain persons are inclined to laugh at them.

How often would the physicist, disheartened by so many checks, have fallen into discouragement, if they had not had, to sustain their confidence, the brilliant example of the success of the astronomers! This success showed them that nature obeys laws; it only remained to know what laws; for that they only needed patience, and they had the right to demand that the sceptics should give them credit.

This is not all: astronomy has not only taught us that there are laws, but that from these laws there is no escape, that with them there is no possible compromise. How much time should we have needed to comprehend that fact, if we had known only the terrestrial world, where each elemental force would always seem to us in conflict with other forces? Astronomy has taught us that the laws are infinitely precise, and that if those we enunciate are approximative, it is because we do not know them well. Aristotle, the most scientific mind of antiquity, still accorded a part to accident, to chance, and seemed to think that the laws of nature, at least here below, determine only the large features of phenomena. How much has the ever-increasing precision of astronomical predictions contributed to correct such an error, which would have rendered nature unintelligible!

But are these laws not local, varying in different places, like those which men make; does not that which is truth in one corner of the universe, on our globe for instance, or in our little solar system, become error a little farther away? And then could it not be asked whether laws depending on space do not also depend upon time, whether they are not simple habitudes, transitory, therefore, and ephemeral? Again it is astronomy that answers this question. Consider the double stars; all describe conics; thus, as far as the telescope carries, it does not reach the limits of the domain which obeys Newton's law.

Even the simplicity of this law is a lesson for us; how many complicated phenomena are contained in the two lines of its enunciation; persons who do not understand celestial mechanics may form some idea of it at least from the size of the treatises devoted to this science; and then it may be hoped that the complication of physical phenomena likewise hides from us some simple cause still unknown.

It is therefore astronomy which has shown us what are the general characteristics of natural laws; but among these characteristics there is one, the most subtile and the most important of all, which I shall ask leave to stress.

How was the order of the universe understood by the ancients; for instance, by Pythagoras, Plato or Aristotle? It was either an immutable type fixed once for all, or an ideal to which the world sought to approach. Kepler himself still thought thus when, for instance, he sought whether the distances of the planets from the sun had not some relation to the five regular polyhedrons. This idea contained nothing absurd, but it was sterile, since nature is not so made. Newton has shown us that a law is only a necessary relation between the present state of the world and its immediately subsequent state. All the other laws since discovered are nothing else; they are in sum, differential equations; but it is astronomy which furnished the first model for them, without which we should doubtless long have erred.

Astronomy has also taught us to set at naught appearances. The day Copernicus proved that what was thought the most stable was in motion, that what was thought moving was fixed, he showed us how deceptive could be the infantile reasonings which spring directly from the immediate data of our senses. True, his ideas did not easily triumph, but since this triumph there is no longer a prejudice so inveterate that we can not shake it off. How can we estimate the value of the new weapon thus won?

The ancients thought everything was made for man, and this illusion must be very tenacious, since it must ever be combated. Yet it is necessary to divest oneself of it; or else one will be only an eternal myope, incapable of seeing the truth. To comprehend nature one must be able to get out of self, so to speak, and to contemplate her from many different points of view; otherwise we never shall know more than one side. Now, to get out of self is what he who refers everything to himself can not do. Who delivered us from this illusion? It was those who showed us that the earth is only one of the smallest planets of the solar system, and that the solar system itself is only an imperceptible point in the infinite spaces of the stellar universe.

At the same time astronomy taught us not to be afraid of big numbers. This was needful, not only for knowing the heavens, but to know the earth itself; and was not so easy as it seems to us to-day. Let us try to go back and picture to ourselves what a Greek would have thought if told that red light vibrates four hundred millions of millions of times per second. Without any doubt, such an assertion would have appeared to him pure madness, and he never would have lowered himself to test it. To-day an hypothesis will no longer appear absurd to us because it obliges us to imagine objects much larger or smaller than those our senses are capable of showing us, and we no longer comprehend those scruples which arrested our predecessors and prevented them from discovering certain truths simply

because they were afraid of them. But why? It is because we have seen the heavens enlarging and enlarging without cease; because we know that the sun is 150 millions of kilometers from the earth and that the distances of the nearest stars are hundreds of thousands of times greater yet. Habituated to the contemplation of the infinitely great, we have become apt to comprehend the infinitely small. Thanks to the education it has received, our imagination, like the eagle's eye that the sun does not dazzle, can look truth in the face.

Was I wrong in saying that it is astronomy which has made us a soul capable of comprehending nature; that under heavens always overcast and starless, the earth itself would have been for us eternally unintelligible; that we should there have seen only caprice and disorder; and that, not knowing the world, we should never have been able to subdue it? What science could have been more useful? And in thus speaking I put myself at the point of view of those who only value practical applications. Certainly, this point of view is not mine; as for me, on the contrary, if I admire the conquests of industry, it is above all because if they free us from material cares, they will one day give to all the leisure to contemplate nature. I do not say: Science is useful, because it teaches us to construct machines. I say: Machines are useful, because in working for us, they will some day leave us more time to make science. But finally it is worth remarking that between the two points of view there is no antagonism, and that man having pursued a disinterested aim, all else has been added unto him.

Auguste Comte has said somewhere, that it would be idle to seek to know the composition of the sun, since this knowledge would be of no use to sociology. How could he be so short-sighted? Have we not just seen that it is by astronomy that, to speak his language, humanity has passed from the theological to the positive state? He found an explanation for that because it had happened. But how has he not understood that what remained to do was not less considerable and would be not less profitable? Physical astronomy, which he seems to condemn, has already begun to bear fruit, and it will give us much more, for it only dates from yesterday.

First was discovered the nature of the sun, what the founder of positivism wished to deny us, and there bodies were found which exist on the earth, but had here remained undiscovered; for example, helium, that gas almost as light as hydrogen. That already contradicted Comte. But to the spectroscope we owe a lesson precious in a quite different way; in the most distant stars, it shows us the same substances. It might have been asked whether the terrestrial elements were not due to some chance which had brought together more tenuous atoms to construct of them the more complex edifice that the chemists

call atoms; whether, in other regions of the universe, other fortuitous meetings had not engendered edifices entirely different. Now we know that this is not so, that the laws of our chemistry are the general laws of nature, and that they owe nothing to the chance which caused us to be born on the earth.

But, it will be said, astronomy has given to the other sciences all it can give them, and now that the heavens have procured for us the instruments which enable us to study terrestrial nature, they could without danger veil themselves forever. After what we have just said, is there still need to answer this objection? One could have reasoned the same in Ptolemy's time; then also men thought they knew everything, and they still had almost everything to learn.

The stars are majestic laboratories, gigantic crucibles, such as no chemist could dream. There reign temperatures impossible for us to realize. Their only defect is being a little far away; but the telescope will soon bring them near to us, and then we shall see how matter acts there. What good fortune for the physicist and the chemist!

Matter will there exhibit itself to us under a thousand different states, from those rarefied gases which seem to form the nebula and which are luminous with I know not what glimmering of mysterious origin, even to the incandescent stars and to the planets so near and yet so different.

Perchance even, the stars will some day teach us something about life; that seems an insensate dream and I do not at all see how it can be realized; but, a hundred years ago, would not the chemistry of the stars have also appeared a mad dream?

But limiting our views to horizons less distant, there still will remain to us promises less contingent and yet sufficiently seductive. If the past has given us much, we may rest assured that the future will give us still more.

After all, it could scarce be believed how useful belief in astrology has been to humanity. If Kepler and Tycho Brahe made a living, it was because they sold to naïve kings predictions founded on the conjunctions of the stars. If these princes had not been so credulous, we should perhaps continue to believe that nature obeys caprice, and we should still wallow in ignorance.

THE PROGRESS OF SCIENCE

THE SMITHSONIAN INSTITUTION AND ITS SECRETARY

THE regents of the Smithsonian Institution at their annual meeting on January 23 elected Dr. Charles D. Walcott to succeed the late Samuel Pierpont Langley as secretary of the institution. Born in New York State in 1850, Dr. Walcott became assistant in the Geological Survey of the state in 1876, passing to the U. S. Geological Survey in 1879. In 1894 he succeeded Major Powell as director of the national survey, which under his administration has enjoyed an unprecedented development, the annual appropriation by congress for its work being in the neighborhood of $1,500,000. The survey has been criticized for bureaucratic methods, for trespassing on fields occupied by other geologists and for turning out a vast amount of routine work rather than discoveries of the highest order. To this it is replied that the efficiency of a government bureau, especially one that is rapidly developing, requires adequate business management, that the spirit of cooperation and research in the survey is excellent, that when a new institution develops on a large scale a certain amount of temporary conflict of interests is inevitable, that the standing of geologists in the survey is as high as of those in the universities, that indeed in no single science in any institution in the world are there so many men engaged in scientific research.

When the Reclamation Service was established by the congress, its extensive work in irrigation was placed under the Geological Survey, and it has been carried forward with an efficiency and economy comparing most favorably with the conditions on the Isthmian Canal. When the service was well organized it was separated from the survey. On the organization of the Carnegie Institution, Dr. Walcott became secretary, and was responsible for a large share of the administrative work. He, however, withdrew from this position after Dr. Woodward's election to the presidency. He was also for a short time acting-assistant secretary of the Smithsonian Institution in charge of the National Museum, and has been since 1892 honorary curator of paleontology in the museum.

Dr. Walcott was vice-president of the American Association for the Advancement of Science in 1903, has been president of the Washington Academy of Sciences since 1899 and became a member of the National Academy of Sciences in 1896. He has received the doctorate of laws from Hamilton, Chicago, Johns Hopkins and Pennsylvania. He has become eminent for his researches on the stratigraphy and paleontology of the lower Paleozoic formation and the sedimentation, stratigraphy and contained faunas of the Cambrian formation.

The acceptance of the secretaryship of the Smithsonian Institution involves unusual responsibilities. It is generally regarded as the highest scientific office in the country; indeed it is possible that a too obvious halo has been painted about the head of the secretary. The organization of the institution is such as to give to him great, perhaps undue, powers. The regents are the vice-president and the chief justice of the United States, six congressmen and six citizens. They have, as a rule, met for an hour or two once a year to listen to the report of the secretary; they have neither time nor competence to direct the policy of

the institution. The conditions are somewhat similar in many of our universities, but there the faculties have a certain moral control, however limited their statutory rights. So far as appears in the annual reports, there is not a single scientific man, except the secretary, on the Smithsonian foundation, and the scientific men employed in the dependencies are likely to receive the salaries and treatment of departmental clerks. Thus the late secretary could write in his annual report in regard to the Bureau of American Ethnology: 'The actual conduct of these investigations has been continued by the secretary in the hands of Major Powell,' and he could appoint a successor to Major Powell and alter the title from director to chief without the advice of the regents or of any body of scientific experts.

It is well known that a large part of the scientific work under the government had its origin in the Smithsonian Institution, but Henry, the first secretary, was always ready to relinquish work that could be done elsewhere, leaving to the Smithsonian what it only could do. The opposite policy has been followed in recent years, and the National Museum and other agencies supported by the government have not only been kept under the Smithsonian, but have been subordinated to the personal control of the secretary. The propriety of using Smithson's unique bequest for the support of governmental institutions is doubtful, and the result has not been favorable. The National Museum, for example, whether regarded as an educational or research institution, is insignificant when compared with the Museums of Natural History and Fine Arts in New York City, or the similar institutions of foreign nations.

It may be unwise to detach the various governmental agencies from the control of the Smithsonian regents at present, or so long as we have no department of science and education. Directors should, however, be found for the National Museum and other agencies, and scientific men of high standing should be attracted to these institutions, who should be permitted to guide their policies, subject only to the ultimate control of the regents, which should naturally be exercised only on rare occasions and under competent advice. We should like to see the Smithsonian Institution itself devoted to the broad purposes of its foundation 'the increase and diffusion of knowledge among men,' and under existing conditions this could perhaps best be accomplished by some form of cooperation and affiliation between it and the scientific men and scholars of the country and the world.

THE REPORT OF THE PRESIDENT OF THE CARNEGIE INSTITUTION

WHEN the Carnegie Institution was established five years ago, many American men of science hoped that it would fill the position that the Smithsonian Institution had relinquished, and become a center for the higher scientific and intellectual life of the country. But such vague visions are difficult to realize in concrete performance. It is disappointing that the Carnegie Institution has been able to do nothing beyond making grants to certain scientific men and founding certain research institutions along well-established lines, but it may none the less be difficult to say what else it could do to better advantage. Money spent on scientific research is almost surely well spent. If the undertakings of the Carnegie Institution are what in commercial life would be called three-per-cent. investments, in science they bring a material return manyfold as large, and the ideal results are not to be measured.

It is somewhat surprising, therefore, to read in the report of President Woodward that "after careful examination of the facts at hand I think it safe to state that no direct return may be anticipated from more than half of the

small grants made up to the present time for minor researches and for research assistantships." There are given in the report the names of forty individuals and institutions which have received minor grants and of six research assistants, and they appear to be of about the same standing and largely the same individuals as those who have received grants in previous years. It is not easy to decide which grants the president refers to in his report, as it might be supposed that every one of them would yield direct returns. The grantees include many of our most eminent men of science, such as Professors S. Newcomb, W. W. Campbell, L. Boss, A. A. Noyes, T. W. Richards, T. C. Chamberlin, R. S. Chittenden, E. L. Mark and E. B. Wilson, and it is inconceivable that money entrusted to them would not be spent to advantage. It is, however, possible that equally good results would have been obtained if twenty of the grants had been distributed by lot among members of the National Academy of Sciences and the other twenty among the fellows of the American Association, and this would have obviated the suspicion of favoritism and indirect influence which is almost inevitable when such largesses depend mainly on the decision of a single individual.

The president recommends that in general minor grants shall be given only to eminent investigators who shall for the time become research associates and advisers of the institution. That the institution needs a board of scientific men is obvious. Its trustees, as is usual in America, consist mainly of prominent men of affairs, most of whom are too busy to give attention to the control of the institution, even if they were competent to do so. The secretary, originally an eminent resident man of science, is now a business man of New York City. The by-laws speak of special advisers and advisory committees, but if such exist they are not mentioned in the annual report. The only possible reference in the by-laws to the scientific men who should be the institution is a clause to the effect that the president 'shall have power to remove and appoint subordinate employees.' If the trustees could fulfil their proper function in the care of the property, and the president could be a constitutional executive officer, and there were a legislative board consisting of scientific men, elected by the scientific bodies of the country, a great advance in organization would be effected. Perhaps we may hope that the advisers nominated by the president may ultimately become a board of this character.

The larger projects of the institution last year were: botanical research, D. T. MacDougal, director; economics and sociology, Carroll D. Wright, director; experimental evolution, Charles B. Davenport, director; historical research, J. F. Jameson, director; horticulture, Luther Burbank; marine biology, A. G. Mayer, director; meridian astrometry, Lewis Boss, director; nutrition, F. G. Benedict, R. H. Chittenden, L. B. Mendel and T. B. Osborne; solar physics, George E. Hale, director; terrestrial magnetism, L. A. Bauer, director; work in geophysics, F. D. Adams, G. F. Becker, A. L. Day. For these departments the sum of $552,000 was appropriated, the largest grants being: Solar Observatory, $150,000; geophysical research, $115,500, and terrestrial magnetism, $54,000. Appended to the president's report are extremely interesting accounts of the research work accomplished under the large projects and minor grants. Illustrations showing the site of the solar observatory and the laboratories for experimental and marine biology are here reproduced.

MR. ROCKEFELLER'S GIFT TO THE GENERAL EDUCATION BOARD

MR. JOHN D. ROCKEFELLER has announced his intention to give, not later than April 1, securities valued at about

$32,000,000, to the General Education Board, which he had previously endowed with $11,000,000. The letter announcing this gift, read at a meeting of the board on February 7, is as follows:

New York, Feb. 6, 1907.
General Education Board,
54 William Street,
New York City.

Gentlemen: My father authorizes me to say that on or before April 1, 1907, he will give to the General Education Board income-bearing securities, the present market value of which is about thirty-two million dollars ($32,000,000), one third to be added to the permanent endowment of the board, two thirds to be applied to such specific objects within the corporate purposes of the board as either he or I may, from time to time, direct; any remainder not so designated at the death of the survivor to be added also to the permanent endowment of the board.

Very truly,
JOHN D. ROCKEFELLER, JR.

The board has acknowledged this great gift in the following terms:

The General Education Board acknowledges the receipt of the communication of February 6, 1907, from Mr. John D. Rockefeller, Jr., a member of this body, announcing your decision to give to the board for the purpose of its organization, securities of the current value of $32,000,000. The General Education Board accepts this gift with a deep sense of gratitude to you and of responsibility to society. This sum, added to the $11,000,000 which you have formerly given to this board, makes the General Education Board the guardian and administrator of a total trust fund of $43,000,000.

This is the largest sum ever given by a man in the history of the race for any social or philanthropic purpose. The board congratulates you upon the high and wise impulse which has moved you to this deed, and desires to thank you, in behalf of all educational interests whose developments it will advance, in behalf of our country whose civilization for all time it should be made to strengthen and elevate, and in behalf of mankind everywhere, in whose interests it has been given and for whose use it is dedicated.

The administration of this fund entails upon the General Education Board the most far-reaching responsibilities ever placed upon any educational organization in the world. As members of the board, we accept this responsibility, conscious alike of its difficulties and its opportunities.

We will use our best wisdom to transmute your gift into intellect and moral power, accounting it a supreme privilege to dedicate whatever strength we have to its just use in the service of men.

The work of the General Education Board has in the main been confined to gifts to certain denominational colleges on condition that they collect three times the amount appropriated, but the present gift is not limited to higher education. It is said that agricultural education in the south will be especially assisted. It will be observed that Mr. Rockefeller and his son reserve the right to dispose of two thirds of the capital in accordance with the purposes of the board. This is a wise provision, as the money would probably be of greatest use if distributed to assist existing institutions without other conditions than their deserts, or to establish new institutions. A centralized control of higher education, however indirect, has dangers as well as advantages.

SCIENTIFIC ITEMS

M. CHAUVEAU, of the section of agriculture, has been elected president of the Paris Academy of Sciences to succeed M. Poincaré, of the section of mathematics.—Professor Ernest W. Brown, who this year goes from Haverford College to Yale University, has been awarded the Adams prize of Cambridge University, for his work on the motion of the moon.—Professor William James, of Harvard University, our most eminent student of philosophy and psychology, celebrated his sixty-fifth birthday on January 11, and retired on January 22 from the active work of his chair.